SOUTH AFRICA AND SCIENCE

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Athlone

SOUTH AFRICA AND SCIENCE

A Handbook

Prepared under the auspices of the South African Association for the Advancement of Science for the Meeting of the British Association in Capetown and Johannesburg, South Africa, 1929.

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Printed for
THE SOUTH AFRICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE
by Hortors Limited, Johannesburg.

1929.

PREFACE.

This Handbook has been prepared for the purpose of informing members of the British Association about our country, and about some scientific aspects of it. In the preparation of the book, we have been stimulated by the hope that the information may add to the interest of their visit.

In order to keep the Handbook of reasonable size and of general interest, the space available to the several authors was strictly limited; this has been a serious handicap, as they would all willingly have treated their subjects more exhaustively. The limitation is, to some extent, regretted by the Editors, but it is hoped that it has achieved the object in view, namely, that the whole of the Handbook shall have a general interest to members of the British Association.

On behalf of the South African " British Association " Committee, we tender thanks to His Excellency the Governor-General for the interest he has taken in our endeavours, and for the Foreword which he has contributed.

It is difficult adequately to thank the contributors of the several articles which make up the Handbook. Their willing and eager co-operation bears testimony to the enthusiastic interest which has been taken locally in the British Association Meeting in South Africa in 1929.

We gratefully acknowledge the courtesy of Miss Wilman in allowing us to reproduce photographs from the Cronin Collection in the McGregor Museum, Kimberley, and we thank her for providing illustrations of a Bushman painting, a Bushman engraving and a glaciated rock-surface.

Those who desire fuller information, particularly of a statistical nature, on such subjects as Government, Education, Public Health, Agriculture, Industries, Population, etc., are referred to the Official Year Book of the Union (published at 5s.).

The Transvaal Chamber of Mines intimates that visitors who may desire further information concerning the Gold Industry, can obtain a brochure entitled " Gold on the Rand " (1927) by applying to Room 33a, Chamber of Mines Building, or to P.O. Box 1162, Johannesburg.

THE EDITORS.

Johannesburg,
May, 1929.

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Alice

FOREWORD.

It gives me great pleasure to furnish a brief foreword to " South Africa and Science " for, despite certain difficulties which such a task must involve for the layman, I am thereby afforded an opportunity of welcoming on behalf of the people of the Union the distinguished company of scientists which is visiting this Country.

It is now twenty-four years since the British Association for the Advancement of Science visited South Africa to hold a joint meeting with the South African Association, which had been formed only a few years previously, and on that occasion, 380 overseas members attended. On this present occasion, our visitors have almost doubled their numbers—a significant proof of the increased facilities for intercommunication which are so essential to intellectual co-operation, and also an indication of interest in the scientific life of their Country which all South Africans will interpret as a welcome tribute to their efforts.

Among those who are to attend the present meeting as guests of the Association, it is a great pleasure to notice the names of distinguished representatives from foreign countries, to whom South Africa will offer a most cordial welcome. I wish further to make special mention of those among our visitors who were also present at the 1905 meeting. They are to be congratulated that the passage of time has lessened neither their enthusiasm nor their energy, and they may rest assured that their reception in South Africa will be no less cordial than it was four-and-twenty years ago.

It was on that occasion that the South African Association for the Advancement of Science prepared a volume dealing with Science in South Africa, and a

comparison of what is there recorded with the information contained in the present Handbook will show that there has been a steady advance in the amount and quality of the scientific work in South Africa during the intervening years.

This work is concentrated in three main divisions. Firstly, there is the work done directly in Government Departments, in establishments such as the Onderstepoort Veterinary Station, where work of a routine and research character is always in progress. The Botanical Survey is another example of a purely Government supported research; while the South African Institute for Medical Research at Johannesburg, which is rather State-aided than State-supported, carries out many researches in connection with human diseases, more particularly those associated with mining, in which field the work on Miners' Phthisis is of world-wide repute.

Secondly, important research work is carried out at the Universities, where the spirit manifesting itself affords a most hopeful outlook for science. The research at the Universities is wider in its range than is often the case in institutions founded for a specific purpose, and University workers are to-day making their contributions to Medicine, to Natural Science, to Mathematics, and to the study of Native races and languages.

Thirdly, our Museums serve as centres of research, and their staffs are constantly engaged in original work in varying fields, while closely related to the work of the Museums is that of the National Botanic Gardens at Kirstenbosch, where an attempt is being made to develop research in economic botany.

South Africa owes much to the world's scientists, and particularly to their achievements in that sphere which, for lack of a better term, is usually called applied science. For instance, the safe delivery in London of supplies from the orchards and vineyards of the Union

has only been made possible by the most minute attention to questions of refrigeration, sorting and packing—all matters which turn ultimately on the proper application of scientific principles. Again, the experiments in stock-feeding carried out by the Department of Agriculture at various stations have had most valuable results, not least amongst which is the discovery of "Woolly Finger Grass" (*Digitaria eriantha* var. *stolonifera*)—a discovery which may well revolutionize farming conditions in many of our drier districts.

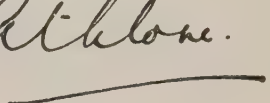
Yet, notwithstanding the undeniable progress in Science which has been made during the last 24 years in this Country, it cannot be denied that there are certain *lacunae*, the more remarkable when it is realised that South Africa offers almost unlimited opportunities, and in some respects unique opportunities, for scientific, economic, and sociological investigation.

For instance, in a predominantly agricultural country such as this, it is a matter for regret that up to the present comparatively little attention has been paid to the study of meteorology; a branch of science, moreover, which has additional interest to South Africa in view of the expansion of aviation and the development of air routes; for which a study of the higher reaches of the atmosphere is of the greatest importance. Another omission, which we must hope will in due time be corrected, is the neglect of the scientific study of marine biology. The Cape Peninsula has perhaps the most favourable situation of any place in the world for the close exploration of this subject. Attempts have been made from time to time to obtain adequate funds for this end, and in view of the future which may be confidently expected for the fishing industry in this country, it is of very real consequence that steps should be taken to study and conserve these great natural resources.

But in a country of rapid development, of wide and varied interests such as this, it is perhaps not altogether unnatural that here and there may occur oversights and omissions, not indeed attributable to any national myopia, but rather to a desire to explore without loss of time the regions of new discovery which are constantly appearing. It is in these circumstances that a visit such as we are now to receive from the British Association, and our distinguished guests, is so particularly valuable, for the impressions which they must gain of our problems will be unbiassed by familiarity, they will be fresh and untrammelled by those preconceptions with which unconsciously our outlook may in some cases have been partially obscured. Again, it is beyond doubt that the meetings and discussions which are to be held will tend to focus general interest on scientific subjects amongst our population, and further impart a new impetus to scientific study in this country, suggesting new lines of thought and new directions for research. In return, we may venture to hope, the widely differing aspects of Nature with which they will meet in South Africa, contact with our social and economic problems, and the opportunity of examining at first hand the tendencies of this rapidly developing country, will prove of interest and value to our visitors.

That they will everywhere receive a sincere welcome goes without saying, and in addition we trust that from their stay amongst us they will derive such stimulus to thought and such variety of new impressions as shall more than repay them for the long journey which they have undertaken.

GOVERNMENT HOUSE,
PRETORIA,
24th April, 1929.



I.

SOUTH AFRICA AS A TRAVEL LAND.

By the South African Railways and Harbours Publicity Department.

At the Cape of Good Hope.—The sea voyage to South Africa is the fair-weather voyage of the world. It alone repays the traveller for coming so far abroad. And, if he knows what he is coming to, there is exhilaration when, sixteen days out of Southampton, Table Mountain looms on the horizon to stir him with anticipation of that exquisite country which lies around and behind the mountain.

When the "Grand Trade" went round the Cape of Good Hope, before the Suez and Panama Canals were constructed, Table Mountain was the principal signpost on the world's greatest highway. At its foot in Table Bay, the voyagers, after three months at sea, forgathered with relish. Whatever their nationality, or the extent of their travels, few writing from the Cape in those days omitted to record their admiration of the beauty of the flora, the charm of the mountain setting and the attractive climate.

Capetown was then the world's half-way house—a remote outpost of civilisation and hospitality. To-day it is one of the world's fairest cities.

In profile, Capetown is not unlike Naples; from Seapoint to Hout Bay, then across the isthmus to Sir Lowry Pass and Gordon's Bay, is a classic and almost Ionic environment, of mountain-girt bays, and fertile mountain-girt valleys, with forests of pine and oak trees, picturesque views between the mountains and the sea, old and romantic-looking mansions in the woods, and vineyards on the foothills.

The surrounding Peninsula is uncommonly beautiful. On landing, one's first impression is of the familiar. The principal thoroughfares present on a modified scale life as it is in the pleasanter towns of Britain. There are the same well-dressed crowds and suggestions of general culture.

But there the resemblance to a British town of quality ends. The place is as much Dutch as British. Everybody speaks English, but Afrikaans (South African Dutch) is freely used in the home and Parliament, in the church, law courts, and a section of the press. French is no longer current, and the descendants of the Huguenots approximate nearer to the Dutch than to the British.

A racial peculiarity that does, however, impress itself, is, that of its population of about two hundred and fifty thousand, nearly half is of Malay or Bantu descent. This colour element, together with the sunny and vivacious atmosphere, the mountain setting, and a foliage of southern richness, combines to give Capetown an air that is foreign but cordial. The bay in front of Capetown, on a cloudless day, lies blue as a Pacific lagoon. In the background, so close that its shadow creeps into the city, is the mountain, and for twenty miles along the foothills are the suburbs.

It is a land of flowers. In an area smaller than the Isle of Wight, there are two hundred more species of wild flowers than in the whole of England. The National Botanic Gardens of Kirstenbosch gives splendid opportunity to botanists to study them.

The Cape is noted for its roads. The principal of these runs along a circular mountain route, skirting the sea, from Capetown to the Cape of Good Hope, a distance of a hundred miles for the round trip, in the course of which one travels along the edge of the Atlantic, and then along the edge of the Indian Ocean, in surroundings varied and impressive. Indeed, many travellers acquainted

with the world's show places, have concurred in terming this the finest of marine drives.

A Survey of the Union of South Africa.—The Union is less than one-twentieth the size of the continent of which it forms part, and by no means the most densely populated portion of that continent ; but with its equipment for studying and perhaps solving the problems of Africa, the Union is most important. Climatically, it is probably unique. Socially, it resembles the older communities of the United States, having the same foundation of Dutch, British and Huguenot blood. Yet, in essentials, it differs in that, besides its long-established European population, it has a large and growing black population, with a sprinkling of Asiatics, mostly Indians, each race preserving its characteristics yet living in amity and steady progress.

Paradoxical as it may seem, South Africa is on the whole, little known. Everybody has heard of its mineral wealth, but comparatively few outside the Union have any conception of its other claims to attention. Eulogies suggesting that were its pleasant places better known, they would be thronged, have been bestowed unstintingly, even by those acquainted with the best elsewhere. But the eulogies were generally oral, did not carry far enough to make the attractions of South Africa as widely known as those of, say, Italy or Japan, and the world-wide prominence given to the country had reference to its gold and diamonds rather than to the country itself—its scenery, its climate and its romantic past.

Twenty or more years ago, when the railway, shipping and hotel facilities of South Africa were not nearly as good as now, the country was too remote, entailed too much discomfort and expense on travellers to be popular as a resort ; and the attractions of Europe and the then novel East, were still too absorbing for travellers to seek new fields. It is different to-day. The remotest part of

South Africa can be reached and enjoyed with ease and comfort, and not only have the travelling facilities been modernized, but the attractions to which they lead are fresh and uncommon.

The exquisite scenes that distinguish the Cape Peninsula have already been noted. No less vividly beautiful in a sub-tropic fashion are parts of Natal and the Transvaal.

The by-ways are also noteworthy. Around Pietermaritzburg and Bloemfontein, as around Port Elizabeth and East London ; on the upper altitude of the Transvaal and Free State, as in the bushveld or in the forests of Knysna ; even on the arid Karroo, genial skies, clear breadth of existence, almost daily sunshine, and many interesting people, conduce to a serene enjoyment of this field of travel.

The attractions of the Transvaal, Natal and Rhodesia may not be quickly apparent to the newcomer. South Africa does not reveal itself with the orderly sequence of a stage effect. Its places of outstanding interest are generally far apart, and often that part of the intervening territory traversed by the railway may, to the casual glance, appear uninviting. For miles the eye of the uninitiated detects little to kindle enthusiasm. Nothing apparently stirs, not much grows. The hills soon cease to attract attention, the sparsely peopled plateaux oppress by their monotony. Here and there a lonely farm is seen, here and there perhaps a drooping horseman, and at intervals a discoloured stream coaxing a sun-wearied plantation from a sun-baked earth.

The Great Karroo.—Much of the Great Karroo, the Transvaal high veld, and Natal is of this description, as is much of America, Australia and Asia.

The Karroo, according to the late Professor Schwartz, was a flower garden two or three hundred years ago, "supporting vast herds of game, the present dry rivers running throughout the year."

Plate 1.] CAPETOWN AND TABLE MOUNTAIN.

To that condition the Karroo may return, when the conservation of water is more thoroughly understood and practised in South Africa. Given increased conservation, together with scientific dry-farming to make the most of what rainfall is conserved, many thousands may find excellent livings, and some fortunes, on the Karroo. Peach, apple and orange orchards may one day stretch from its horizons, fields wave with corn, and prize cattle stand deep in lucerne.

Sometimes even the little rain the Karroo normally gets, is withheld for a season or two. Then the streams dry up, cattle and sheep starve, and much financial loss is the result. But, after even successive droughts, the rainfall of one season need be only a few inches above the normal when all that was previously lost is regained. Given water, anything might be done with the Karroo. This has been proved at Oudtshoorn, where the waters have been led to the Karroo soil, and where, in consequence, the farming community is normally one of the richest in the world.

The Orange Free State and its Towns.—No South African province has made more notable progress agriculturally in the last twenty years than the Orange Free State, and even greater developments are before it, notably in the irrigation projects, large and small, which promise to revolutionize the productivity of the drier regions.

Diamonds are found in the western portion of the province, and coal in the northern.

Situated on a high plateau almost in the sub-tropics, there is warmth yet crispness in its atmosphere. The summer days are often hot, but never enervating; usually the nights are cool, still and starry. In winter little rain falls, and then only at long intervals.

Much of the Free State resembles the Karroo, but most of it is prairie-like—great grassy plains hundreds of square miles in area. They are diversified in places by solitary kopjes, low ridges, or even wooded river valleys.

There are just over two hundred thousand Europeans in the Free State, though it is nearly as large as England ; indeed, the whole of the Union has a white population smaller than that of a capital town in many other countries. Hence most South African towns are small judged by European standards, but nearly all are prosperous and growing.

Bloemfontein is the capital with a population of fifty thousand, of which twenty-three thousand are Europeans. It is seven hundred and fifty miles from Capetown, and through its central situation and good railway connections in every direction, is a convenient meeting-place. Most of the important conferences are held there, and it was the place where President Kruger and Sir Alfred (later, Lord) Milner met, in 1899, in an endeavour to avert the Anglo-Boer War. There the aim of statesmen for generations past, to bring the people of South Africa into one fold, was achieved in 1909 when the foundation of the South African Union was laid.

Kimberley and the Valley of Diamonds.—Kimberley is about one hundred miles due west of Bloemfontein, and probably nowhere else has so much wealth been won from so small an area as at Kimberley. From four mines, the aggregate dimensions of which are under two hundred acres, diamonds worth nearly three hundred million pounds sterling, have been taken in just over fifty years.

Like so many outstanding South African events, the discovery of diamonds in 1867 was accidental. A travelling trader, attracted by the lustre of a pebble with which a farmer's child was playing, conceived the idea of having it identified. It proved to be a diamond. The

few farmers on the frontier were informed, and a little semi-official prospecting was undertaken. Nothing, however, resulted, and for a year the opinion that South Africa had a diamond field was discredited. Then the country was thrilled by another discovery. The " Star of South Africa," a superb gem worth £25,000, was picked up on the banks of the Vaal River.

This proved to be the veritable " valley of diamonds," and from Durban and Capetown thousands of people flocked inland fired by the lust for weath. By 1870, though there were only a few miles of railway in the country, hundreds were eagerly delving on the banks of the Vaal River. By the end of that year, the number was estimated at thousands.

Unfortunately, the luck which all expected did not come to all. There were plenty of diamonds on the river diggings, but not the quantities first supposed, and even those were so distributed as to result in the greatest inequalities for the diggers. Therefore, when rumours of far richer fields at Kimberley, about forty miles away, began to filter through, the exodus from the river was rapid, and by the end of 1871 it was almost complete.

The main difference between the river diggings and the dry diggings is that in one the diamonds carried by flood are widely scattered, so that the claims extend for miles, with apparently no uniformity of richness ; whereas in the dry diggings the diamonds, gathered probably by volcanic action, repose in compact pipes or funnels running into the bowels of the earth.

In time, as the Kimberley excavations grew, and retaining walls between the claims caved in, millions of tons of valueless ground began to bury the workings, and costs increased. Gradually, the individual miner was eliminated, the proportion of diamonds to the quantity of earth handled decreased, selling prices threatened to fall, as there were no means of regulating the market, and amalgamation became necessary.

How, on the one hand, to buy out vested interests at reasonable prices, and on the other hand to convince investors that the interests were worth buying out, was an undertaking that might well have appalled the promoters of amalgamation, in which case Kimberley would have become a deserted mining camp. The occasion produced the man—Cecil Rhodes—who not only convinced the investing public, but succeeded in reconciling the apparently irreconcilable local interests affected.

Then open-pit mining was abandoned for the underground methods of to-day. The huge craters which had roared with so much activity, and had been the scene of so many failures and successes, grew silent, and the miners, now working in tunnels lit by electricity and ventilated by compressed air, delved out of sight gradually deeper.

The extent of operations is illustrated by the fact that from 70,000 tons of blue ground (the weekly turnover), only 10¼lb. of diamonds are recovered.

The Influence of the Voortrekkers.—In the development of South Africa, there arose a distinct people known as the Trek Boers. They formed the first outposts of civilization in South Africa. To them must be credited much of the opening up of the country, but they must be debited also with much of the conservatism that tempered the development of the country. The Trek Boer was, however, peculiarly fitted by temperament and habit to deal with the marauding and truculent natives then roaming over the land. But the odds were often against him, massacres at times occurred, and at best he and his family lived in jeopardy. Yet military assistance from the authorities was, as a rule, neither offered nor expected, and, though left to his own resources, the frontiersman was able sometimes to strike a shrewd blow, and sometimes to recover his herds and other property that the natives had stolen.

Such liberty of action, though precarious, was jealously valued by the remoter settlers as their only means of redress against the natives. The authorities at the Cape, however, claimed the right of interference and veto in the affairs of the frontier. In the circumstances of the case, it was declared, such interference, however well-intentioned, was in practice likely to prove irritating and futile, because as it brought no accession of strength to the unprotected white man, it was likely to hamper more than it helped him.

So it was that unrest spread throughout the country, and fainter grew the prospect of goodwill, not only between whites and blacks, but between the authorities and the frontiersmen. To crown the discontent, that admirable, but badly administered Act, the Emancipation of Slaves, was placed on the statutes.

In the South Africa of that day most Europeans, certainly all the upper classes, were slaveholders, and many were enlightened enough to admit and even urge the measure. The compensation ultimately accorded, however, was not only far below the value which the owners set on their slaves, but was made payable only in London, thus giving rise to further irritation.

The settlers felt that the time for a change had come. Large numbers decided to leave what is now Cape Province, and to establish their own rule elsewhere. North of the Orange River, the land was practically unoccupied. They decided to go there. The Great Trek, or exodus—probably the most dramatic incident in the history of South Africa—commenced in 1836, gained impetus, continued for some years, and drained the Cape—already sparsely populated—of thousands of people. This movement attracted people of many types and of many nationalities besides Dutch, a great number of the best families of the country being included.

When they reached what is now the Free State, there, as once before in the history of a wandering people, was the wilderness between them and neighbouring civilized peoples ; there also was the Ethiopian, who harried the stragglers ; there was the lofty plateau, with a rainfall like the " former rains " of the Old Testament. Indeed, the analogies the Voortrekkers drew between themselves and the chosen people of old, were so apt that they were led to name the villages they founded after biblical originals—such as Bethulie, Bethesda and Bethlehem.

After some notable battles with the natives under Moselikatze and the notorious Dingaan, the Voortrekkers established themselves in the Transvaal. Potchefstroom was, for a time, the seat of Government, until, in 1864, the scattered bands united and declared the Transvaal a republic, with Pretoria as the capital.

The Administrative Capital—Pretoria.—A modern town with many charming features, Pretoria still retains, in parts, reminders of the old atmosphere and regime. Certain cottages have an unfading interest. Jess's cottage, the scene of Sir Rider Haggard's romance, is such a one. Even more so is a place in Church Street West, a simple bungalow once the home of Paul Kruger.

His Honour was an early riser and little addicted to formality or state trappings. It was his custom, from about five in the morning till breakfast-time, to meditate and take the air on his verandah facing the street. There with coffee-urn and tobacco jar at elbow, he had an open ear for anyone with a grievance or a plan worth discussing, and much that was to have the profoundest effect on South Africa was informally set afoot there in the early morning hours.

Pretoria to-day is the centre of South African officialdom, where the Governor-General, Ministers of State and the principal officials reside for most of the year, and

where, consequently, the policy of the country is largely shaped. The city has developed much in recent years. Westward, there is a considerable and increasing number of factories and workshops. Eastward, there are fashionable suburbs, with fine villas, wide lawns and roads lined with jacaranda and plane trees, and in the centre is the business area. The zoological gardens, parks and museums of Pretoria are attractive and interesting, as is Church Square in the centre of the town, flanked as it is by effective structures such as the Law Courts, Provincial Government Building and the Post Office.

But even if Pretoria had nothing else to commend it, it would still be worth visiting to see the Union Building. It is as noble an edifice as will be found in the Southern Hemisphere. It provides offices for some two thousand officials, and has an auditorium capable of accommodating about nine thousand people. The building, a little over a mile from Church Square, is commandingly situated on Meintjes Kop, overlooking the city.

The immediate hinterland of Pretoria is a remarkable one, rich in minerals, especially coal and iron, and even richer in agricultural possibilities. Blast furnaces have already been established, and will probably lead to the development of a great steel industry. The Premier Mine, thirty miles from Pretoria, is to-day the largest of open-worked diamond mines. The largest white diamond ever known was found in this mine. This was the "Cullinan," which weighed 1¼lb. avoirdupois. It now forms part of the British Crown Jewels.

Johannesburg and the Gold Reef.—On a plateau nearly six thousand feet above sea level, and forming the summit of the water-shed between the Indian and Atlantic Oceans, is the world-famed Witwatersrand, or "ridge of white waters."

That ridge is famous, not for its white waters, but for its gold. For by a happy chance there runs through it

veins composed of quartz pebbles and gold-bearing silicious cement. These veins dip to the south for several thousand feet below the surface. They have a thickness varying from a few inches to twenty feet, and extend through the rock, practically unbroken for over sixty miles, like golden threads carelessly drawn. This is the greatest gold deposit known, from which at present well over half the world's annual gold supply is produced. To reach these golden veins, shafts were sunk, and so for sixty miles there is a string of mines, in the centre of which is Johannesburg.

The gold, as produced on the mines, is sent to the Rand Refinery at Germiston, the largest gold refinery in the world, where, after treatment, it is cast into ingots for shipment.

Two and a half million tons of rock are put through the mills on the Witwatersrand every month. The accumulation of powdered rock, after it has been treated, is an enormous one, and forms the so-called cyanide dumps, white hills, like mounds of damaged flour, which abut on Johannesburg for thirty miles east and west.

From the pulverised rock composing these dumps, gold to the value of nearly a thousand million pounds sterling has been taken in forty-two years, and has transformed an uninhabited, naked, and not particularly prepossessing piece of veld into the largest and wealthiest town in South Africa—a town with a well-built area of eighty-two square miles, containing more than eight hundred miles of streets and a population of over three hundred thousand.

The mining area is, however, only a part of Johannesburg, and no index to the wealth and even beauty of its other parts. Much though it forces itself on the notice of anyone coming to, or going from, Johannesburg, the mining area by no means overshadows the place as a

Plate 2.] UNION BUILDINGS AND PRETORIA.

whole. Indeed, in so large a place, a resident might live for years without having the mining area obtruded on him.

Johannesburg being the natural clearing house of a large and rich farming area, has become a city of considerable and growing manufacturing and commercial importance. More and more the surrounding country is being put under cultivation, and what two or three decades ago was treeless veld, has become an area of great productiveness and much sylvan beauty.

The principal business thoroughfares of the city form an area well-equipped with fashionable shops, residential flats, modern hotels and restaurants. Within that area there are nine theatres and other places of amusement, half-a-dozen large clubs, and, in fact, general amenities and appointments worthy of any large city.

On the outskirts there is the Country Club. The famous Wanderers Sports Ground and Joubert Park lie between the commercial centre and the residential portion of the town, and Auckland Park and Turffontein, Johannesburg's two racecourses, are farther out.

The ridges and valleys occupied by Johannesburg lend themselves to picturesque effects in landscape gardening and architecture. Indeed, it is no exaggeration to say that there are more beautiful gardens in Johannesburg than in most towns, and perhaps a greater variety of pleasing styles of architecture.

Johannesburg is nine hundred and fifty-seven miles from Capetown, and it is one of the few African towns of which at least the name, if not the fame, is known throughout the world.

Durban and Natal Province.—Durban, which is four hundred and eighty-two miles, or twenty hours, by rail from Johannesburg, abuts on the Indian Ocean. It is one of the principal watering-places and ports of South Africa.

The dominant note of Durban is the glossy greenness of an abundant vegetation, and to the visiting eye there is about the town, despite its European ways, more that is foreign than familiar. The streets are modern—the architecture of the buildings, and so forth are such as one might find anywhere in Europe. Even the sunshine is much what one expects, but does not always get, along the Mediterranean. But there the semblance ends, and in every picture there is evident the flamboyance of the sub-tropics and the Orient, mingled in a fashion to intrigue and fascinate. The foliage and the Orientals—Indian men and women mostly dressed in their native garb—are flamboyant, and so in a more robust degree are the brawny Zulus clad according to their own ideas of adornment. The fantastic and exotic qualify every view. Though on the hills where the fashionable residences are, the purr of many motors and the clang of the tram are heard, the note that strikes the fancy is the tinkle of the ricksha bells.

The story of Durban is a brief and simple one ; the place has had too few rufflings of fortune to have many annals, but viewing the scene from the Berea, one is reminded of Christmas Day, **1497**, when the first European ship to enter those waters passed that way. These first Europeans sailed under da Gama, but others, hardly less adventurous, followed. Natal was never a port of call for them ; it was too far off the highway between Asia and Europe. But between it and the old voyagers, there was a sombre association, for they sometimes paid a heavy reckoning, and sometimes paid it on the coast of Natal.

Shipwrecks were plentiful. The historic "Grosvenor," with its gallant band, foundered in the vicinity, one of a long list of ships that found a grave in those seas. Indeed, until recently, there was visible on the sands near the Umzimvubu River a touching memorial of the

kind—the mouldering ribs of the great galleon "Sao Joao," which after being buried for generations, was disclosed by the drifting of the sands.

Prominent among Durban's commercial interests is the handling of sugar, and along the coast the tillers and reapers will be seen in sugar plantations that extend for hundreds of miles. The industry is one of the most interesting spectacles in South Africa.

Farther inland there are large wool, cattle and grain farms, and coalfields. These, together, have combined to develop Durban. It has grown rich, and besides growing important commercially has become a holiday resort, especially popular in winter. For when chill winds blow across the high veld, when inland mountains are capped with snow, and the Cape Coast is stormy, the Durban climate is at its best—mildly warm, bright and alluring.

Pietermaritzburg, seventy-one miles from Durban, is the capital of Natal. The city is in the enviable position of being close to, though beyond sight of, great and busily worked coalfields, and it is in the centre of extremely rich farming areas where sugar, tea, meat, maize, cotton, tobacco, dairy products, wool, and many kinds of fruit are produced in abundance. Indeed, many of the finest estates in South Africa are in the vicinity.

Socially and educationally Pietermaritzburg has much to commend it. It was Natal's capital before the South African provinces united in 1910, and it is still an important scholastic centre, the seat of a provincial council, and the See of a Bishopric. Its situation, well over two thousand feet above sea level, in a district of rare beauty, makes the town popular not only as a place of residence, but as a holiday resort, and when the heat haze hangs like a blanket over the coast, it is to Pietermaritzburg and the little stations nestled above it that the Natalians themselves flock for relief.

For those who with rod, oar or gun, desire recreation amid pleasant surroundings, the trout streams, mountains and valleys within easy reach of Pietermaritzburg are a source of contentment. And for those who like a touch of the romantic about the places they visit, there is much about the associations of the city that is tragic and even dramatic. Few places have made bigger sacrifices in the cause of civilization; few deserve a warmer regard whether from Boer or Briton. As a sort of buffer against the barbarian, when to live outside the three or four comparatively populous centres was to live constantly in jeopardy, it has time and again stemmed native invasion. No town in South Africa, size for size, has paid a heavier toll, or had more fateful issues decided in its vicinity.

South Africa's National Parks.—Two of South Africa's National Parks are outstanding in their attractions, the one a scenic wonderland in the Drakensberg range, the other a natural zoo of such dimensions as to make it the largest park in the world.

Occupying practically the whole of the Eastern Transvaal north of the Crocodile River, the Kruger National Park contains specimens of nearly all the fauna for which the sub-continent is renowned. It affords the visitor a means of seeing the wilds under conditions sufficiently safe and comfortable to allow the most timid the same thrills as are enjoyed by the experienced wanderer in other wilds. Shooting is not allowed within the confines of the game reserve, the rangers only being permitted to carry firearms. With a little strategy, however, the visitor may manage to secure photographs of many animals in their natural habitat, a pastime perhaps not so thrilling as the capture of the animal's skin and skull, but at least as distinctive. Access to the park is easily effected by means of the railway that skirts its western boundary.

There is also much to enjoy in the Drakensberg National Park, especially if the visitor takes an interest in botany, geology, serious climbing, painting or photography, and more especially if one is addicted to the seductive pastime of trout fishing.

The Drakensberg, or "Mountains of the Dragons," are to South Africa what the Himalayas are to India and Thibet. They form a rampart six hundred miles long, which separates Natal from Basutoland and the Free State. The highest peaks, Giant's Castle, Cathkin Peak and Mont aux Sources, are far apart, but all are in Natal. Giant's Castle rises to about 12,000 feet above sea level, or more than 7,000 feet above the surrounding country; but Mont aux Sources, 10,600 feet, is the most popular, partly because it is comparatively easy to reach, but mainly because of its remarkable surroundings. The Tugela Gorge, the Goodoo Pass adjoining, and the foothills and valleys one skirts to reach these, form together, especially in summer, a panorama that for interest and beauty is unexcelled.

The Natives of South Africa.—The coast north of Durban has a special interest, particularly in Zululand, where native life may be seen, if not unaffected by civilization, yet at least unspoilt.

As there are in the Union of South Africa over six million natives out of a total population of seven and a half millions, more than passing reference is justified if the visitor is to have some conception of the various people among whom for a while he will travel, for wherever he goes in South Africa there will be natives, as they are distributed throughout the country, and not localised in any part of it.

The known history of the South African Native is remarkable neither for antiquity nor for profusion of reliable detail. It goes back only a few hundred years,

and has to be substantiated in many essentials. Such as it is, however, it indicates that of the main types—Bushmen, Hottentots and Bantus—the Bushmen and Hottentots first occupied the country, and the Bantus came from the north probably not more than three hundred years ago. They came from Central and East Africa to Natal and the Cape Province, and in doing so swept the now almost extinct Bushmen into the mountains and deserts; some of the Hottentots were driven to the western coastal belt, and others were absorbed into the more virile life of the new-comers, where their identity was soon lost, so that to-day the South African natives are nearly all of Bantu blood.

Of the natives who live in and around the towns, many have found useful and respectable niches as domestic servants, chefs, waiters, porters, coachmen, gardeners and navvies.

Generally, however, the native is a backwoodsman. He may serve a term on a farm or a mine, or in a town, but usually shows little trace of the experience after he has resumed life in the native kraal. Most natives, however, never leave home, and know the world only by repute. Living thus, the native has affairs supervised and regulated by European magistrates and officials, but many of the old tribal customs and influences remain, except those repugnant to the usages of civilization, and, on the whole, therefore, the native lives much as his forefathers did. He is not the robust soldier or skilled hunter, nor the man of practical resource and great endurance his ancestor was. He is, however, less a brawler and swashbuckler. Though generally too undisciplined to endure daily toil all the year round, he is, on the whole, more industrious than of old. In many respects he is a likeable fellow, presenting ludicrous limitations no doubt, but generally superb of limb and not without dignity of bearing. His memory is retentive,

his power of detecting idiosyncrasy and mimicking it, keen to a fault. But he is not usually able to reason logically, and this lack of contemplation sends him frivolously along the line of least resistance.

There are limitations which have left the average South African native on a low plane socially. Unlike other important races, he has advanced little beyond the rudimentary. As his forefathers were away back in the dawn of history, so in the main does he still appear. Other races have risen or fallen; the natives of Africa have merely increased in number.

Is this the result of poor opportunity or insuperable defect? Given the proper opportunity, can the native develop? A few—Dingiswayo, Tchaka, Moshesh—were notable generals, statesmen and even philosophers; but with them it was a matter not of opportunity, but of merit. Each rose unaided. Each rose superior to his opportunities, not through them. Such cases are so abnormal as to be no criterion.

On the whole, therefore, the native's capacity is an unknown quantity. It is still uncertain how and in what direction he can best be developed.

Experimental education is being extended to the natives. They have in places their own Press, their native teachers of European learning, their own Christian ministers, their own carpenters, masons, bootmakers, tailors, printers, and even a few graduates in law and medicine.

But when the average native returns to the ancestral kraal, there is a tendency to slide back to the blanket and the care-free days of the kraal, perhaps because the backwoodsmen still form the bulk of the race and its most virile section; and the backwoodsman, especially of the old regime, has little patience or respect for innovation. He is still a pagan at heart, loving merriment and good

living, looking on man as a man and woman as a woman, with no impulse for the higher thought.

The Zulu language is strikingly euphonious, with a copious and flexible vocabulary, a language which often polishes and refines even a poor thought and gives to the utterance of the better-class Zulu touches of poetry. But the white man's language penetrates everywhere, and English and Dutch trade and industrial terms are now current even in Zululand.

At all times, and particularly in his leisure moments, the native is prone to music. Especially does he love a dance, when, to the accompaniment of home-made musical instruments, the young men and the young women can display their prowess. This predilection is zealously cultivated even when he leaves the kraal, and on the gold mines of the Rand, the various tribes take great pride in maintaining their dance troupes. Batteries of native pianos, weirdly and wonderfully constructed, and played after the manner of the xylophone, figure prominently in the entertainment. Led by a gaudily dressed Maitre-de-ballet, the dancers go through their performance to the amusement and edification of the spectators, who as a rule are as breathless from excitement at the end of the "show" as the performers from exertion.

It is a spectacle that every visitor to the sub-continent keenly appreciates, and it demonstrates in a fascinating manner how deep rooted are the instincts of the native even when associated with the modern commercial enterprise of gold winning.

Other places of interest.—The following paragraphs deal with some organized tours.

Tour No. 1.—At Nelspruit, 220 miles east of Pretoria, the land has already begun to slope rapidly towards sea level, and the barometer records only 2,350 feet of elevation. The two great divisions of the Transvaal—the

Plate 3.] KAFFIR ORCHESTRA.

Highveld and the Lowveld—are separated by a broken escarpment, and the descent produces a change in conditions as radical as it is sudden. The drop begins near Waterval Boven, 163 miles from Pretoria, and the undulating plains of the upland plateau give place within a few miles to semi-tropical conditions. The flocks of sheep and fields of maize are replaced by orange orchards, papaw groves, and fields of cotton and tobacco. The crisp air of the highlands gives place to a languid warmth. The scenery becomes rugged. This is, veritably, the bushveld—the country beloved of the old transport riders on their trails through the Eastern Transvaal, and the one-time paradise of the hunter. Nelspruit itself and the adjoining area is rapidly becoming an important citrus-growing district.

Twenty miles farther east, at Kaapmuiden, a short line leads southward to Barberton, the scene of one of the many romantic chapters in South African history. It was in 1884 that a prospector discovered the rich gold deposits of the Barberton district. In quick time the country rang with the news. Hundreds of people began the long and hazardous wagon journey from the south to the new mining centre, and soon the hillsides around the roughly-formed camp seethed with a great conclave of adventurous gold seekers—men and women who had braved the wilds to reach this golden haven. Fortune, however, did not smile on the new goldfield ; the quartzite deposits were patchy, and the discovery of the Witwatersrand reef eclipsed the Barberton fields. As rapidly as they had arrived, the adventurers poured out of Barberton. Gold mining, however, is still carried on extensively on more modern lines, and the annual output averages about £250,000. One of the largest asbestos deposits known is in the Barberton district, and magnesite, nickel, talc, and verdite are also mined. Citrus, tobacco, tropical fruits, and cotton are cultivated with considerable success. The town is laid out on a

mountainside overlooking the great De Kaap valley, and the surrounding scenery is distinctly fine.

From Nelspruit a branch line northwards leads through some of the finest scenery in the Transvaal to Graskop, a magnificently situated hamlet, nine miles from the goldfields of Pilgrims Rest. White River is the centre of a large irrigation settlement, where the waters of the river have been dammed to irrigate, eventually, about 2,000 acres for orange growing.

White River is a convenient centre from which to visit the Kruger National Park, South Africa's great game reserve. A road penetrates to Pretorius Kop, a vantage point within easy access, where Zebra, Giraffe, Wildebeeste and other species of animals may often be seen grazing peacefully. The Kruger National Park is one of the few places in Africa to-day where opportunity exists for seeing wild game in its natural surroundings. South Africa has profited by the experience of other countries, and by passing stringent laws against unauthorised and wanton destruction, the fauna of the sub-continent is now being preserved for the advantage of posterity. The game park is 9,300 square miles in area, almost equal to the combined area of Yorkshire, Lancashire and Cumberland, and occupies the eastern border of the Transvaal, contiguous to Portuguese East Africa. Its denizens range from the elephant to the smallest of antelope, and although many of the species have become localised in their own corners of the reserve, the variety of types which it is possible to encounter on a comparatively brief excursion is remarkable. Giraffe, Rhinoceros, Hippopotamus, Elephant, Buffalo, Sable Antelope, Koodoo, Waterbuck, Zebra and Wildebeest, to mention but a few of the larger species, roam undisturbed over the bush-covered plains of this vast natural zoo. They seem to recognise instinctively that here they possess a sanctuary of their own, and, for the most part, evince but

a timid curiosity at the intrusion of a motor car. After dusk, the deep-throated growl of the king of beasts often disturbs the intense stillness of the night, and gives a reminder that, despite the truce with man, game still has to struggle to survive.

About 240 miles from Pretoria, the train passes between the giant walls of Crocodile Poort, one of the grandest sights in South Africa. At Komatipoort, the Komati River claims the Crocodile as a tributary, and the mingled waters rush through a rocky passage in the hills on their journey to the sea. Komatipoort is the frontier town on the borders of Portuguese East Africa. In the early days it held renown with hunters, but to-day there is little activity other than the railway, and the business of the Customs Department. The principal attraction for the visitor is the hippo pools, within two miles of the town, where many of these ungainly creatures still have their home, and are often seen disporting in the river or wallowing on the mud banks. The Crocodile and Komati Rivers are the home of the Tiger Fish. This species is said to provide the most exciting river fishing obtainable, and is found only in waters where crocodiles exist.

Fifty-eight miles beyond Komatipoort on the eastward line, is Lourenço Marques, the capital of Portuguese East Africa, and one of the most important seaports on the east coast of Africa. The town is pleasantly situated on the western shore of Delagoa Bay, and possesses a distinctly continental atmosphere, despite its African setting. The harbour facilities are most modern, and an increasing volume of cargo is being handled for Johannesburg and other Transvaal towns. The town is popular as a winter seaside resort with the people of the highveld. A splendid natural beach with a background of imposing cliffs forms a fine restground for the holiday maker. Pavilions, restaurants, a shark-proof bathing enclosure, a pier, and a fine marine drive have been built; and the climate during the winter months is ideal.

From Komatipoort a branch line to the north-west cuts through the southern portion of the Kruger National Park, in traversing which the watchful traveller will seldom go unrewarded. Many animals are to be seen grazing fearlessly in full sight of the carriage windows, while others screen themselves furtively in the shade of some clump of trees or scamper off in herds away from the passing train. Excepting a few, small, widely-scattered Shangaan kraals, there is no population in the reserve, and the country served by the railway along its western boundary is also sparsely populated. It is, however, rich in both minerals and agricultural potentialities. The sidings Mica and Corundum are named after mineral deposits in their neighbourhood, and gold and copper have been exploited in the vicinity of Leydsdorp, with platinum a little further afield. The agricultural pursuits are confined to sub-tropical products and winter market gardening.

At Tzaneen, 200 miles from Komatipoort, citrus and tomatoes are cultivated extensively, while sugar, tobacco, and cotton are giving excellent results. The country is well wooded, and the scenery to the west of the line is notable for its spectacular beauty. A motor highway connecting Tzaneen with Pietersburg, traverses Magoeba's Kloof, through what is known as the "mist country," where the late Sir Rider Haggard laid the scene of some of his well-known romances, and gave the name of "the twin breasts of Sheba" to two mountains in the neighbourhood.

The hamlet of Duivelskloof is tucked away in a mountain vale, fifteen miles north of Tzaneen. Forestry provides the principal occupation, and a wide variety of agricultural products gives indication of the fertility of the soil. Ground-nuts are produced in abundance, and a scheme is afoot to manufacture food products on a large scale.

The railway line links up at the village of Zoekmakaar with that from Pretoria, and trailing away to the north from this point is the railway to the copper mines of Messina on the Limpopo River, the northern boundary of the Transvaal. The river is at present being spanned by a rail-and-road bridge, which is being constructed by the Beit Trust, and some day the line will be carried on to West Nicholson in Rhodesia, thus providing another great road to the north. Fifty miles south-west of Zoekmakaar is the town of Pietersburg—the most important centre in the Northern Transvaal. Despite a checkered history, the district has progressed rapidly ; its wealth of minerals and the suitability for agriculture of the surrounding countryside having brought about its present-day prosperity. The exotic forest scenery in the neighbourhood of Woodbush makes this area one of the most distinctive corners of the Transvaal. North of Pietersburg lies one of the finest shooting districts in the country.

The 170 miles of line separating Pietersburg from Pretoria traverses, for the most part, rich farming lands, and one passes successively, tobacco plantations, cotton fields, papaw groves, mango trees, and the orderly rows of citrus estates.

From Johannesburg to Durban the route unfolds a profusion of scenic wealth, rich in reminders of the Anglo-Boer War of thirty years ago, and of other historic events that figured prominently in the early history of Natal. Directly after crossing the border at Charlestown, the line goes over Lang's Nek, where Colonel Deane fell in the War of 1881, and shortly afterwards it skirts the base of Majuba Hill, where General Sir George Colley met his death. The battlefield of Elandslaagte is passed about eighty miles farther south just before entering Ladysmith, the scene of the memorable siege which was so outstanding an incident of the Boer War. Spion Kop,

a hill whose name is indelibly inscribed on South African history, is 18 miles by road from Ladysmith, while Wagon Hill and Nicholson's Nek are within walking distance of the town. The great hump of Umbulwana mountain, which played a great part in the siege, overlooks the town.

Sixteen miles south of Ladysmith, and on the main line, is the battlefield of Colenso, where Lieutenant Roberts, son of the late Field Marshal Lord Roberts, lost his life in an endeavour to save the guns, for which act the V.C. was awarded. Colenso is now the site of the central power station for the 175-mile stretch of electrified railway in Natal—Glencoe to Pietermaritzburg

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Tour No. 2.—The stretch of country lying south-west of Bloemfontein along the line to Port Elizabeth, though semi-arid in appearance, is excellently suited for sheep farming. Southward the line passes over a portion of the Great Karroo, prior to reaching the irrigated areas of the Sundays and Fish Rivers and entering upon the sharp descent to the sea.

Port Elizabeth lies widespread on the shores of Algoa Bay, and is the second city of the Cape Province. Its history dates from 1820, when a party of over 3,000 English settlers, sent out by the British Government in the hope of affording relief from the depression caused by the Napoleonic wars, landed in the bay and faced the task of converting what was then a wild and inhospitable tract into a habitable countryside. The story of their perseverance, and the hardships they endured, stands out in the history of the early settlement of the subcontinent, and one of the first things to capture the attention of the visitor to Port Elizabeth is an imposing column, erected in a commanding position as a memorial

to their efforts. The town was given its name by Sir Rufane Donkin, then Governor of the Cape, in memory of his wife, Lady Elizabeth, and a stone pyramid on Donkin Reserve bears the inscription, "……one of the most perfect of human beings, who has given her name to the town below."

Port Elizabeth is a flourishing and modern seaport, doing a considerable ocean trade. It is also important as a manufacturing centre, its industries including foundries, flour mills, jam, confectionery and biscuit works, tanneries, boot factories, fruit canning, and soap, oil and candle works. Two large American motor companies have assembly works at Port Elizabeth.

The holiday visitor at Port Elizabeth makes for Humewood Beach, about two miles from the centre of the town, where all the amenities of an up-to-date seaside resort have been provided, and sea-bathing has a special allure. An intriguing feature of scientific interest is the Snake Park, where hundreds of snakes are housed in the open, and are separated from the onlooker by only a small moat and a low brick wall. Although their poison fangs have not been extracted, the native attendant handles them with the utmost *sang froid*.

The immediate hinterland of Port Elizabeth is full of reminders of the 1820 settlers. The scholastic city of Grahamstown owes much of its present-day importance to their labours. Bathurst, their first administrative centre, is now in the midst of large pine-apple estates. Port Alfred, a popular resort on the Kowie River, and the site of one of South Africa's many fine golf courses—the Royal Port Alfred—is situated a little way eastward, up the coast.

Leaving Port Elizabeth, the route leads north-west past the flourishing town of Uitenhage to Klipplaat Junction, where the line bends back in the direction of the coast, and skirts the southern edge of the Great

Karroo. Between Uniondale Road and Willowmore, the railway enters an awesome defile known as Toverwater Poort. The walls of this massive canyon tower precipitously on either side, leaving only a narrow strip of sky to relieve the sombre effect of this passageway through the mountains.

Oudtshoorn, one of the richest agricultural districts of the Cape Province, first achieved prominence through ostrich farming in the days when Fashion decreed that nodding plumes should be worn. That industry, however, served a capricious mistress, and Oudtshoorn had to adjust itself and adopt more stable pursuits. Ostriches are still to be seen in great numbers, but lucerne, fruit, vegetables and tobacco, have come to be the mainstay of the farmers.

The Cango Caves, 18 miles from Oudtshoorn, are classed amongst the finest limestone caverns in the world. A good road leads to the entrance at the foot of the Zwartberg range. The caves were discovered by a hunter in 1780, and since that time the maze of subterranean passages and fairy-like chambers has been explored for over two miles. Under the electric flood-lights there is a mixture of the bizarre and the beautiful in the multitude of weird effects. The walls and pillars sparkle as if studded with a myriad gems, and those who are fancy-free will find giant gargoyles leering from the gloom, fairy grottoes, and a host of caricatures in limestone, glimmering in the halls and passages of the Cango Caves.

After leaving Oudtshoorn, the line begins to climb the Outeniqua Mountains. The conquest by rail of the Montagu Pass is one of the triumphs of South African railway engineering. The scenery is spectacular in the extreme ; the track winds round giant bluffs, past great mountain spurs, and along the edges of awesome gorges. At a slightly lower level, the roadway holds a parallel course to the railway, until, zig-zagging down

Plate 4.] THE SENTINEL, MONT-AUX-SOURCES, DRAKENSBERG MOUNTAINS.

the farther side, both run into the charming little city of George.

George is the centre of one of the most alluring regions of South Africa. Motor roads radiate through a countryside that is renowned for the wealth and variety of its scenery, embracing dark forests, towering mountains, waterfalls and lakes. The city itself (it is the See of a Bishopric), with its oak-lined avenues and quaint cottages, has an atmosphere of rustic tranquillity and old-world charm.

A branch line that, for the greater part of the way, hugs a rocky shore, connects George with the forest town of Knysna. Kaleidoscopic views of rivers, lakes, forests and the surf-beaten coast flash past the carriage windows. Knysna is three miles from the sea, on a land-locked estuary, and small steamers ply between this place and the larger ports with cargoes of timber from the surrounding forests. "The Heads", the guardian cliffs at the mouth of the estuary, are worthy of a visit. The town was founded early in the 19th century, by George Rex, a one-time Commissioner of the British Admiralty at Simonstown. The only industry of the district hinges upon the vast natural forests that extend inland behind the town, and in which herds of elephant still exist in the more remote corners.

The route is retraced to George, thence along the coast to Mossel Bay, a popular holiday resort and one of South Africa's minor ports. The harbour was one of the first known to European navigators in South African waters, and it is recorded that Portuguese ships took refuge here as far back as 1501. A feature in Mossel Bay is "The Poort," a natural swimming pool on the edge of the breakers. Seal Island, about three miles out in the bay, is a sanctuary for these mammals, and great numbers are always to be seen.

From Mossel Bay to Capetown is styled " The Garden Route." On either side of the way there is a passing pageant of rolling hills, deep valleys, great mountains and rippling streams. The country traversed is, moreover, a rich agricultural area, and its picturesque farmsteads and fields add to the natural beauty of the scene. Small townships are clustered at the foot of the mountains. Riversdale, Heidelberg, Swellendam and Robertson are passed in turn before Worcester is reached, the junction station on the main line between Johannesburg and Capetown.

Hereafter the line follows the valley of the Hex River, with the majestic mountains of the same name towering around, and winds through the heart of South Africa's most fruitful orchard-land. Vineyards stretch on either side of the line for miles. South African wines, vinted locally, have established a reputation in England, and peaches, plums, nectarines and pears grown in this district are largely exported to London.

The picturesque towns of Paarl and Wellington, with their romantic relics of the early settlement of the Cape, are passed en route, and finally, the great hump of Table Mountain looms ahead.

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Tour No. 3.—Ladysmith is an important agricultural and industrial centre. Thirty miles to the west the great wall of the Drakensberg range towers skywards. In the region of Mont aux Sources (the highest peak and the mother of five rivers, including the Orange) is the National Park, where the mountaineer, the trout fisherman and the lover of nature will find a wealth of scenic splendours and sport aplenty. Lofty spires, deep ravines, and massive buttresses vie with the quieter beauties of rippling streams and fern-clad dells. Here

also, during the rainy season, is one of the highest waterfalls in the world (2,200 feet).

Ladysmith itself will live in history for the siege, and the tide of war which seethed around it in the campaign of 1899-1902. Nearby is the great bulk of Umbulwana mountain, from which the Boers skilfully bombarded the town with the big gun which was nicknamed "Long Tom," and skirting Ladysmith is the river which the besieging forces endeavoured to divert into the town by building a great barrier of sand-filled sacks across it. The fields of Caesar's Camp, Wagon Hill, Nicholson's Nek and Spion Kop, are all within easy access.

The railway line crossing into the Orange Free State passes over a spur of the Drakensberg at van Reenen's Pass, and runs down into Harrismith, the companion town to Ladysmith on the farther side of the mountains.

Harrismith, in the south-eastern corner of the Orange Free State, is reputed to enjoy one of the healthiest climates in the country. The altitude of 5,350 feet, and the proximity of the Drakensberg range, ensure a delightful and invigorating climate, which has had some effect on the popularity and prosperity of the surrounding countryside.

The town had its earliest beginnings as an outpost in the eastward advance of the early European settlers, and for many years was a storm centre. It took its name from Sir Harry Smith, Governor of the Cape, and the name of his wife is commemorated in Ladysmith. From its earliest years Harrismith assumed importance as a trading centre, largely on account of its centrality and its position as the gateway between the Cape and Natal. That importance it has retained, and it is now one of the principal trading centres in the Orange Free State.

A pleasant river courses through the town, and the massive Platberg forms a most impressive background. Harrismith is a convenient point from which to visit Mont aux Sources, and other notable peaks in the Drakensberg range and Maluti mountains. The drives radiating from the town open up a wealth of fine mountain scenery.

Verdite, referred to on page 21, is a green serpentinous rock used as an ornamental stone.

II.

SOUTHERN RHODESIA.

By Major W. R. FORAN, F.R.G.S., F.J.I., etc.

Southern Rhodesia—the very name conjures up vivid memories of a truly great Pioneer and Imperialist, Cecil Rhodes—besides boasting of one of the best climates in the world, some of the most magnificent works of Nature in the world, and historical monuments of past races of people, also enjoys the distinction of being the youngest self-governing Colony in the British Empire. So it is that the Colonist living therein can justifiably feel that he is helping to make history, while the casual visitor can see a country that is yet in the making, but which has made enormous strides in the past forty years. It is a record of achievement that must engender pride in all who have taken part in that progress, and in those who see what has been accomplished in so short a span of time, and in the face of such long odds.

So far as European occupation is concerned, Southern Rhodesia is only about forty years old, and it is but six years since the Rhodesians decided that the time was ripe for the institution of self-government. Since the actual occupation of the country in 1890, progress has been most marked and well maintained. In addition to Salisbury, the capital and seat of Government, and Bulawayo—the chief commercial centre, the gateway from the south, and the *entrepot* for Northern Rhodesia and the Congo—a number of thriving towns have sprung into existence and display marked degrees of sound development. To mention only a few of these: Umtali, the beautiful town and gateway to the eastern

port of Beira, is a frontier outpost that ranks third in importance; Gwelo, the capital of the Midlands, is the rapidly growing centre of large agricultural and mineral interests; Gatooma, the fifth in size, is also the heart of large mineral and agricultural interests; and Fort Victoria, near where are the famous Great Zimbabwe Ruins, is still another rich agricultural and mining area. A number of lesser townships, such as Enkeldoorn, Gwanda, Hartley, Melsetter, Shabani, Selukwe and Marandellas, are forging ahead and placing themselves firmly on the map of the Colony. And, last, but by no means least, Wankie and its coalfield must be reckoned with.

In the past few years the expanding figures of revenue and expenditure, of imports and exports, and of mining and agricultural output, display clear indications not only of progress, but also of the country's vast possibilities for future development. It is no stretch of the imagination to state that there are no limitations to the future, provided the necessary capital and hard work are forthcoming; in fact, the possibilities of the country have, so far, been little more than scratched. Its greatest needs, at the present time, are white population, the fuller and closer settlement of its rich agricultural and pastoral lands, and additional capital adequately to develop its vast mineral and other resources.

Whereas the world-famous Victoria Falls at one time had a "season," that season has now extended itself to such a degree that it covers the whole period of the year. The Great Zimbabwe Ruins are also attracting an ever-increasing number of visitors With the opening up of new roads, and the improvement of those that already exist, the motor tourist traffic is on the increase, and the field of travel within the Colony is being vastly broadened. The Matopo Hills and the grave of the honoured Founder of Rhodesia, the late Cecil John

Plate 5.] VICTORIA FALL.

Rhodes; the Khami Ruins near Bulawayo; the Sinoia Caves near Salisbury; the glories of the "Alps of Rhodesia"—Melsetter, Chipinga and Mount Selinda; the beauties of Umtali and its picturesque surroundings, and the many other scenic masterpieces of the Colony are rapidly gaining world-wide renown, and becoming distinctly popular with the travellers of modern days. The climate of the Colony is ideal; malarial fever is at a discount, provided reasonable precautions are exercised. Rightly has the Colony been styled "Sunny Southern Rhodesia."

Endowed with efficient railway services, and with motor roads that compare favourably with those in older parts of the world, Southern Rhodesia's future is assured. To-day it is possible to travel about the country in ease, safety and comfort, where less than half a century ago no European could venture without fear of being overwhelmed by the savage impis of the brutal and despotic ruler of the Matabele—King Lo Bengula. From barbaric savagery to the modern amenities of civilization is no mean record to have attained in a period of thirty-six years. These facts speak well for the hardy spirit of the pioneers of the Colony, and for *Pax Britannica*.

Historical.—The recorded history of Rhodesia is generally thought to antedate the Roman Conquest of Britain. References to gold won from the land which is now Rhodesia, are found in the works of Persian and Arabian geographers or historians between the years 915 A.D. and 1060 A.D.; and the Portuguese writers described the gold regions of Rhodesia between 1485 and 1760 A.D. They stated that the territory was known as Abutwa—the land of the little people. The name Abutwa still appears on some of the earliest maps of Rhodesia.

There seems sufficient evidence to prove that the Bushmen were the aborigine occupiers of the country from back in the remotest time, and that they were for

very many centuries in undisturbed possession, at any rate down to about 700 or 800 A.D.; the Bantu hordes then arrived south of the Zambesi and either exterminated them or drove them southwards. Small and isolated parties of the Bushmen continued for some time afterwards to live in the more inaccessible and mountainous sections of the country. But, finally, even these few lingerers were exterminated.

The Portuguese adventurers endeavoured to occupy the territory many centuries ago, but they were eventually driven out by the prevalence of, and mortality caused by, malarial fever and other diseases. There is evidence available that 400 years ago there were Portuguese officials at Mount Darwin and at other places in what is now known as north-eastern Mashonaland. In various parts of the country, most notably near Inyanga, there are the remains of irrigation and other agricultural works of a type far superior to anything accomplished by any known native races in Africa; but the builders, unfortunately, have left no written record of their identity.

Ancient gold workings, also undated, are found in great numbers—some of which are extensive, but never below water level. In the Gwanda District, the skeleton of a Bantu female was discovered in an old mine-working, and this has been estimated by scientists to be at least ten centuries old, thus supplying evidence as to the date of some of the ancient gold recovery operations. There are also over four hundred ancient stone buildings, some of them of considerable area—such as the Zimbabwe and Khami Ruins. The mystery of their origin still awaits definite solution. For many years it was assumed that they were co-temporaneous with the ancient gold workings, but later investigations by Professor Randall-MacIver suggest that the oldest do not date beyond mediaeval times. It is expected that the British Association's expedition to Zimbabwe, under the leadership of

Miss Gertrude Caton-Thompson, and the German expedition under Dr. L. Frobenius, will throw a new light on its ancient history, and, at the same time, settle definitely the controversy that has raged about the origin of these ruins.

The discovery at Broken Hill of the skull of an extinct type of man, carries the human occupation of Rhodesia into prehistoric times. The skull is of the Neanderthal type, and Neanderthal man in Europe is supposed to have become extinct about the close of the last Glacial Period. In the more favourable conditions of Africa, the type may have survived to a much later date ; but, at the lowest computation, the Broken Hill skull must be many thousands of years old.

There is not a large volume of recorded history of Rhodesia until comparatively recent times. A Portuguese missionary reached Zimbabwe in 1561, but was martyred there by the King of the Monomotapa Empire, thus becoming the first known Christian martyr in Africa. Eight years later, Francis Barreto led a punitive expedition against the Empire of Monomotapa, but he failed in his mission owing to his small force being decimated by disease on the journey up from the coastal port of Sofala. The Portuguese records describe Zambesia in 1667, but there is a hiatus until 1849, when David Livingstone, the intrepid missionary-explorer, entered the country. Six years later he discovered the Victoria Falls. Apart from his writings, very little more was heard of the territory until Frederick Courteney Selous, the famous hunter-naturalist, visited Mashonaland in 1872, the year before the death of Dr. Livingstone.

In 1888 Lo Bengula, the King of the Matabele and Mashonas (the latter title oft disputed, but probably correct in view of conquest), signed the famous Rudd Concession. With the incorporation of the British South Africa Company in 1889, the modern history of Rhodesia

may be said to have begun. The title of Rhodesia was given, with the Imperial sanction, in 1895. The two provinces of Southern Rhodesia are known as Matabeleland and Mashonaland, the former because it was occupied by the Matabele—an offshoot of the Zulus, who, under Mzilikatzi, were driven across the Limpopo River by the Boers about 1837. The latter name, according to Selous, was a coined word intended as a generic title for all the tribes of South-East Africa who were not of Zulu blood. The whole of Zambesia was proclaimed a British sphere of influence on 20th July, 1888.

On 19th April, 1890, a Pioneer Column, consisting of 187 Europeans and 150 natives, and accompanied by two troops of Police who joined the force at Tuli, left Mr. Rhodes' farm near Kimberley, to write another great page in British history. After a long trek northward, they arrived on the present site of Salisbury, on 12th September of that same year. They had advanced through Fort Victoria, and there established the first European settlement in Rhodesia. Forts were built at both Fort Victoria and Salisbury, and then the Pioneer Column was disbanded to occupy the lands and to develop the newly-acquired Colony of the British Empire.

The territory owes its name to the late Mr. Cecil Rhodes, still affectionately and admiringly honoured as the founder of Rhodesia. It was to his far-sighted vision and enterprise that the addition of such a rich and important State to the British Empire became an accomplished fact. It was first administered by the British South Africa Company under a Royal Charter, which, after various amendments and renewals, finally expired in 1923, when Responsible Government was granted to the Rhodesians.

By 1893 the work of developing the country was proceeding rapidly. The Vryburg-Bulawayo railway had been begun, and the first section of the Beira railway

Plate 6.] N.-E. WALL, ELLIPTICAL TEMPLE, ZIMBABWE.

had been opened to traffic. A telegraph line was in operation between Mafeking and Salisbury, and some main road construction work had been performed. A sudden check was met in consequence of the Matabele Rebellion in 1893, and it was in the course of these operations that Major Alan Wilson and his gallant patrol were annihilated at the Shangani River early in December of that year. This heroic page in history was quickly followed by the death of Lo Bengula, and the cessation of hostilities.

In December, 1895, occurred a further check on account of the Jameson Raid and its consequences. Rebellions by the Matabele and Mashona were two of these consequences. Colonel Plumer (now Field-Marshal Lord Plumer) led a punitive force from Mafeking in April, 1896, to the aid of the hard-pressed Colonists, and the force reached Bulawayo after a stiff fight at the Khami River at the end of May. The Matabele finally surrendered on 13th October of that year to Mr. Cecil Rhodes, Dr. Hans Sauer, Colonel Johann Colenbrander and Mr. V. Stent. The actual surrender took place at an indaba held in the Matopo Hills. The Mashona Rebellion was finally crushed in July, 1897.

On 26th March, 1902, the great moving spirit of Rhodesia, Cecil John Rhodes, died at Capetown amid universal mourning. He was buried in the Matopo Hills at his beloved beauty spot—the "World's View." Here, to-day, in what has become the Valhalla of Southern Rhodesia, his grave is the Mecca for all Rhodesians and visitors to the Colony, and here they pay homage to the memory of a truly great Empire builder.

A Referendum was held in Southern Rhodesia on 27th October, 1922, as to whether the country should enter the Union of South Africa, or acquire Responsible Government. The voting was in favour of the latter proposal by a majority of 2,785 votes, and as a result,

the Imperial Government in 1923 issued Letters Patent granting self-government to Southern Rhodesia. The election for the first Legislative Assembly took place on 29th April, 1924, though Responsible Government had been in force since the previous October.

It is noteworthy that Southern Rhodesia is the only part of South Africa which has been founded entirely by British enterprise.

Population.—In the case of a relatively new country such as Southern Rhodesia, a measure of the growth of its population is one of the most valuable tests of its prosperity and development. The estimated European population at the end of 1919 was 32,145 ; at the end of 1923 it was 36,670; and on 31st December, 1927, it was 43,330. Over the whole period from 1919 to 1927, the increase in the European population was 11,185 or nearly 35 per cent. The net gain through immigration in 1927 was 1,500, while the increase in income earners between 1919 and 1927 amounted to 6,850.

Industrial Growth—The two main industries of the Colony are agriculture and mining. All other industries are, at present, subordinate to these. Between 1920 and 1927, the area under summer crops increased from 211,000 to 347,000 acres. The major portion was planted to maize, which is the staple crop of the country. Taking the average return to the maize grower as 10s. per bag, the annual value of this single crop has grown from £390,000 in 1916-19 to £560,000 in 1920-23, and £650,000 in 1924-27. Tobacco is the second largest crop, and 20,000,000 lb. of bright Virginian leaf was produced last season.

In regard to livestock, the total number of cattle owned by European farmers has increased from 773,000 in 1920 to 955,000 in 1927. In the dairy industry, the output of milk, which was estimated at about 2,250,000 gallons in 1920, by 1927 had increased to over 5,000,000

gallons. The output of butter had grown from 245,000 lb. in 1920 to 1,710,000 lb. in 1927, or an increase of no less than 600 per cent. in seven years. The value to the farmers, of dairy products sold, has risen from £100,000 in 1920 to nearly £250,000 in 1927.

The export of agricultural, livestock and dairy products of the Colony has grown in value from £1,377,000 in 1920 to £2,301,000 in 1927. It will thus be realised that the aggregate value of the output of the agricultural industry has now attained considerable dimensions.

In the mining industry the output of gold has been influenced by the gold premium and the world-wide rise in the average level of prices, and rose from 552,500 fine ounces in 1920 to 652,000 fine ounces in 1922. Since then a gradual fall in the general level of prices, the restrictions in the use of gold for currency purposes, etc., has caused a decline in the quantity of gold produced; in 1927 the production of gold was only 581,400 fine ounces. Against these results must be set off the increase in the output of chrome ore from 60,300 tons in 1920 to 210,000 tons in 1927 ; of coal from 578,000 tons to over 1,000,000 tons in the same period ; and of asbestos from rather less than 19,000 tons to over 33,000 tons. The total value of all minerals produced in 1920 amounted to £4,451,000 ; and, through many fluctuations in intervening years, it stood at £4,238,300 in 1927.

As regards trade, it may be stated that, compared with 1920, exports of metal and mineral products in 1927, were greater by only 5 per cent., whereas agricultural exports showed an increase of 67 per cent., and re-exports of imported goods nearly 100 per cent. increase. Broadly speaking, the economic condition of Southern Rhodesia in 1927 was about 45 per cent. superior to that of 1922. It is firmly believed that the progress of the Colony during the next lustrum will exceed that of the last.

Communications.—It would be idle to pretend that the Colony is yet covered with a network of railways or good all-weather roads, or that it will be so for some years to come.

The main line connects all the principal centres, and there are branch lines serving other rising places. In order to meet the requirements of sparsely settled districts where railways could not be an economic proposition, a beginning has been made in the running of road motor services, and these are being extended as occasion demands, or are likely to prove economically sound. They are increasingly popular, and will become a big factor in the future progress of the Colony.

In the short span of 35 years there has been developed a comprehensive railway system radiating from Bulawayo to Vryburg in the south, eastwards to Beira, and northward to the Congo Border—a total mileage of 2,522. The approximate number of European inhabitants per mile of railway is about 24, as against about 150 in the Union of South Africa. The capital cost of the combined undertakings as at July, 1927, was nearly £18,000,000, and proposals are now maturing for a bold policy of development which involves considerable capital expenditure. The rapid rise in importance of the Port of Beira, the principal outlet to the markets of the world, can best be indicated by stating the volume of cargo handled. It has risen from 323,985 tons in 1921 to 810,624 tons in 1927, or an increase in six years of 486,639 tons—which is equivalent to slightly over 150 per cent.

The development of road communications in the Colony has been rapid, and the bridging of rivers an outstanding feature in progress. During the financial year 1927-28, a sum of £187,504 was spent on roads and bridges, and approximately £1,500 was given by the Beit Trustees for the construction of bridges on the Fort

Victoria-Messina road. During this period 430 miles of road were constructed, a large mileage was drained, stumped and cleared, while 40 low-level and 2 high-level bridges were erected. The Beit Trustees are now building a magnificent bridge over the Limpopo River, connecting Southern Rhodesia with the Transvaal. It is expected that it will be opened to traffic in July of this year. The new Beit Bridge will carry rail, motor and foot traffic.

Provision has been made in the current year for improvement in local communications. The general policy of the Roads Department is, in the first instance, to concentrate all resources on the permanent improvement of the main traffic roads throughout the Colony, of which there is a mileage of approximately 6,000 at present.

Facilities for Education.—The educational facilities of the Colony are exceptionally good. Naturally, the schools are mainly centred in the larger towns, but schools are also provided in the country. The standard of education throughout the Colony is high, the curriculum ranging from the ordinary departmental syllabus to the full matriculation course; education of a more vocational type is provided in the Bulawayo Technical School for boys intending to enter industrial life, and at the Matopo School for boys intent on agricultural pursuits. Few countries are better served in the matter of Bursaries and Scholarships, including the Rhodes Scholarships. There are also some private schools, where tuition and boarding accommodation are provided at rates slightly in excess of the Government educational tariff. The latter is very low.

Public Libraries—The library movement in Southern Rhodesia is represented by six Public Libraries situated at Bulawayo, Salisbury, Gwelo, Gatooma, Umtali and Enkeldoorn. With the exception of the Queen Victoria

Memorial Library in Salisbury, the libraries are controlled by committees appointed by the subscribers. There is a movement afoot considerably to augment and improve the present system.

Facts and Figures.—The first Governor of the Colony was Lieut.-Colonel Sir John R. Chancellor, G.C.M.G., G.C.V.O., D.S.O., R.E. (now High Commissioner in Palestine), and he was succeeded in 1928 by Sir Cecil Hunter Rodwell, K.C.M.G.

Southern Rhodesia is bounded on the north by Northern Rhodesia and Portuguese East Africa, on the south and west by the Transvaal and the Bechuanaland Protectorate, and on the east by Portuguese East Africa. The total area of the Colony is approximately 150,391 square miles, and the estimated population in April, 1928, was roughly 975,000, of whom 45,000 were Europeans. The native population was then estimated at 926,500, with about 3,500 Asiatics and other coloured or mixed race people.

The revenue of the Colony in 1927-28 was £2,165,000 ; the expenditure was £2,761,000, and the public debt in 1928 amounted to £4,095,000.

Although situated within the Tropics, the general high elevation of the Colony and its inland position prevent its climate from being tropical except in localities below 3,000 feet altitude. The general climate of the settled areas of the country approximates closely to that usually associated with countries in the temperate zone. During the months of September and October, the days are rather unpleasantly warm at times, but the nights are always cool. The greatest daily range of temperature occurs during those two months. The mean annual maximum temperature is 78 degrees Fahrenheit, and the mean annual minimum is 54 degrees Fahrenheit. The normal mean monthly rainfall over the whole country for the period 1898 to 1927 was about 28·89 inches.

Plate 3.1 PARALLEL PASSAGE, ELLIPTICAL TEMPLE, ZIMBABWE.

Taxation is exceptionally light. The only tax on income imposed in the Colony is one based on the gross income from any source within the country. For married men, income is taxed only after exceeding £1,000, and for single men only after £500.

Southern Rhodesia enjoys an economic advantage in what is known as the "Rhodes' Clause." This, which was the result of Mr. Rhodes' exertions and foresight, provided that the Customs duty leviable on any article imported into the Colony, being the produce or manufacture of the British Empire, shall not exceed the duties then in force in the South African Customs Union. The duties at the ports of entry in the south have increased considerably since 1899, and Rhodesian merchants are, therefore, in a favoured position. The usual personal baggage is admitted free, but extra supplies of clothing, etc., are liable to a customs duty of 9 per cent., *ad valorem*.

The Wankie Collieries.—Rhodesia's largest and most important coalfield is that of the Wankie area, which lies between Bulawayo and the Victoria Falls. It is 212 miles by railway from Bulawayo, and 244 miles by motor road, while it is 68 miles by railway south of the Victoria Falls, and 113 miles by road.

Discovered in 1893, the concession covers an area of 400 square miles. The development of the colliery was begun in 1902, after the railway line had reached Wankie, and since then there has been a steadily increased production of coal. The estimated tonnage in the present worked area is 6,000,000,000 tons, and the coal is of good quality. Ten years ago the tonnage hauled from the mine averaged less than 46,000 tons monthly; to-day it is well over 100,000 tons. The European and native population has increased in the same period from 60 and 2,000 respectively to 260 and 8,000. It is estimated that the life of the colliery will not be exhausted even 2,000 years hence. A large coking plant

was established in 1912, and to-day the output capacity amounts to 200,000 tons annually, and a " sales " figure of 185,000 tons has been reached.

The Principal Towns.—Salisbury, the capital, occupies a position at the northern end of the elevated plateau which forms the backbone of Mashonaland. The town is well-planned and the roads are lined with avenues of trees. It has most efficient municipal public services, and water-borne sanitation is being introduced. There is a Municipal Swimming Bath in the Public Gardens, while every modern amenity of civilization is provided and sport is not overlooked. Good roads, pleasant scenery, and sunny, health-giving climate make for enjoyable motoring or walking. In short, Salisbury is a fully developed town, possessing all the hallmarks of civilization, and it is a place where life can be enjoyed in charming surroundings and in a perfect climate.

Bulawayo rose up on the ashes of the abandoned kraal of Lo Bengula. His flight and death form a by no means unimportant part of Rhodesian history, and it is but fitting that a town of such commercial importance should rise as a monument to those who extended the supremacy of Great Britain into the heart of Africa. In December, 1893, Bulawayo was a tent-town on the site of Lo Bengula's kraal (where now stands Government House); in June, 1894, it was removed to its present site. As a Colonial town, Bulawayo is probably unique. Thirty-six years ago it was the centre of the most powerful native despotism existing in South Africa, and it was considered beyond the range of Colonial resources to cope with the trained warriors of Lo Bengula. Where once the " Great Death Dance " of the impis was held, now stands a handsome town with a rateable value of just on £3,000,000. The European population is now in excess of 8,000, while the Natives and Asiatics number approximately 12,000. It has spacious streets,

magnificent buildings, and its shops would do credit to many an older and more settled town in Africa. It enjoys excellent municipal public services, and water-borne sanitation is being introduced. Public Memorials, Public Parks, and a Municipal Swimming Bath testify to the enthusiasm and confidence of the people in the town's future. The War Memorial is one of the most handsome in the world, and is unique ; the Museum possesses, among other fine collections, a mineralogical collection that is as complete as any in South Africa.

Umtali is considered to be one of the most beautiful towns in Southern Rhodesia ; its diversified and appealing scenery, coupled with the proved fertility of its adjoining lands, explain the prosperity and rapid expansion of this area. Umtali is the frontier town and the eastern gateway. Its climate is both brisk and refreshing, and its many attractions have helped to make it increasingly popular. It possesses wide streets, and lies in a hollow surrounded by bold hills. In the flowering season its streets are a mass of scarlet colour from the blooms of the flamboyant trees that flank its thoroughfares.

Gwelo, known as the " Capital of the Midlands," is the fourth largest town in the Colony. It possesses wide tree-lined streets, and its climate is reputed to be the healthiest in Rhodesia. Malaria fever is unknown in the town. The Municipality has established an efficient public service and a Municipal Swimming Bath. It also enjoys the distinction of having the newest and most up-to-date hotel in the Colony. It is an important railway centre, being the junction for five railway lines to different centres.

Gatooma in 1907 was a collection of a few huts and one store. The presence of gold properties in its neighbourhood caused its rapid growth. In the past 22 years, Gatooma has risen from obscurity to be the fifth largest, and one of the most important, towns in the Colony. It is healthy, self-contained and modern, while it enjoys

efficient municipal public services. The streets are wide and well made, and lined with flowering shrubs and trees. The Masonic Temple's foundation stone was laid by H.R.H. the Prince of Wales.

Fort Victoria is the terminus of a branch railway from Gwelo, and is the alighting place for the Great Zimbabwe Ruins, 15 miles distant. It is the oldest town in Southern Rhodesia, having been established in 1890 by the Pioneer Column on arrival from Tuli. Parts of the original fort then built are still standing and provide a landmark in the history of the growth of the Colony. The Town Management Board has installed efficient public services, and its streets are wide and excellently made. The town is particularly well served with hotels, garages, shops and sporting facilities, while its school holds an enviable record of successes in the Beit Scholarships which are competed for annually. It is the rising centre of a rich mineral, pastoral and agricultural area, although at present its European population is but 300, and that of other people about 700.

Retrospective.—That, briefly stated, is the remarkable record of progress and achievement claimed by Southern Rhodesia in less than forty years. It is small wonder that Rhodesians are proud of their country, their achievements, and their birthright. It is no mean record, and can have few equals in the Empire. And, let it be stressed, the progress made by this, the youngest self-governing Colony of the Empire, is built on solid foundations. It has withstood the tests of booms and periods of slump with both composure and bravery. It has smiled in the face of obstacles, and overcome them with grim courage and tenacity of spirit that breathes the best in men of British birth. The work laid down by the fast dwindling band of Pioneers has been carried on honourably to its logical conclusion. Southern Rhodesia looks forward with the utmost confidence to its future, and with just reason for doing so.

III.

GOVERNMENT.

By J. E. HOLLOWAY, B.A., D.Sc.

Historical.—The Union of South Africa was established on May 31st, 1910, the anniversary of the Peace of Vereeniging (1902) which ended the Anglo-Boer War, and it still consists of the four original provinces. All these were founded by the Dutch and subsequently conquered by the British. The Governmental background, therefore, contains elements of both these races. A few words will indicate the main lines of development in each province.

The *Cape Colony* was founded in 1652 by the Dutch East India Company, conquered in 1795 by the British, handed over in 1802 to the Batavian Republic, the heir to the territories of the then defunct Company, reconquered by the British in 1806 and finally ceded to them in 1814. The Government during the Company's period was carried on by a Governor responsible to the Company, aided by a council of officials, assisted on particular occasions by burghers. There were also the elements of local government in the Court of the Landdrost en Heemraden, which was destined to exercise some influence in the later Dutch Republics. During the first British occupation, Government was carried on under the system sometimes known as a " Colonial Autocracy," that is, by a Governor responsible to Downing Street. The Batavian period was marked by the introduction of enlightened ideas at the instance of Commissary-General de Mist, anticipating in certain respects the Durham Report in regard to colonial administration. The next nineteen years saw a revival of the colonial autocracy. From 1825

to 1834 a system similar to that of the East India Company's (that is, a Governor with an advisory council of officials), was in force. After 1834, the Governor's Council was expanded by the addition of non-official members. This system continued till 1854, from which date till 1872 the system of " Representative Government " (an elected legislature, with a Governor and officials not responsible to it) was in force and was succeeded by Responsible Government which lasted till Union.

The *Republic of Natal* was founded by the Voortrekkers in 1838, who created a Volksraad for its Government. The colony was conquered by the British in 1842, and, owing to the emigration a few years later of a large portion of the original Dutch founders, the Colony developed on British lines. It passed through stages similar to those of the Cape, and obtained Responsible Government in 1892.

The *Orange Free State* Republic was founded in 1836. Government was entrusted to a Governor (later, President) and Volksraad, and the old Cape system of Landdrost en Heemraden was later applied to the various districts. It was conquered by the British in 1848, whereon there followed six years of colonial autocracy. Its independence was recognized in 1854, and Government by President, Executive Council, Volksraad, Landdrost en Heemraden continued till its conquest by the British in 1902. Colonial autocracy obtained till 1907 and Responsible Government till Union.

In the territory north of the Vaal several smaller republics were founded by the Voortrekkers, and these amalgamated to form the *South African Republic*. The system outlined in regard to the Orange Free State was generally applied here. The Republic was annexed by the British in 1877, but this step was reversed in 1881. It continued as a Republic until its conquest by Great

Britain in 1902. Colonial autocracy till 1906 and Responsible Government till 1910, complete the catalogue of its systems of Government.

The framers of the South Africa Act, therefore, had before them two systems, of both of which local experience had been gained. There was the British system, modified by the introduction of a written constitution, but retaining to some extent the fictions and usages from which the British constitution derives its elasticity. There was also the Dutch system in which the Grondwet played an important part, and in which there was greater fixity by the fact that the President was elected for a definite period of years. The combination of these two systems in the Act of Union is a subject with some interest for the student of political institutions. Broadly, the British system, as modified under constitutions granting "Responsible Government," was retained for the Central Government. The written constitution observed a golden impartiality between too great fixity and the freedom existing under an unwritten constitution. Thus, while the clauses dealing with the Cape non-European franchise and the official languages are entrenched, other parts of the constitution may be, and in many cases have been, amended by implication in laws not directly relating to the South Africa Act. This law, which was passed by the British Parliament, also makes provision for its own direct amendment by the Union Parliament, which is created by it. On the other hand, the provincial system, with its Administrator, appointed for a fixed period, and advised by an Executive Committee, resembles in some respects the Republican system.

The South Africa Act vests all legislative power, subject to certain restrictions laid down therein, in the Union Parliament. Bills passed by Parliament require the assent of the King, or of the Governor-General, acting for him, before becoming of force.

Certain powers, mentioned below, have been granted to the Provincial Councils. The Union Parliament may, however, pass legislation to regulate the scope of these, or even to abolish the Councils. South Africa is, therefore, in this respect different from the other Dominions and from such federal states as Germany and the United States, in which the component states retain such rights as are not definitely conceded to the Central Government and Parliament. Here it is a case of a Union rather than a Federation of States.

While there is centralisation in legislative authority there is a dualism in several other respects: two white races, two official languages, two flags and two capitals.

Pretoria is the seat of the administration, but Parliament meets in Cape Town. This involves transfer of officials and documents over the thousand miles which separate the two capitals, twice every year, and on occasion more frequently. The adoption of the dual capital system was one of the compromises which were considered necessary to achieve the Union of the colonies.

The Governor-General.—The Inter-Imperial Relations Report of the Imperial Conference (1926) laid down that the Governor-General should hold the same position, in all respects, to the administration of public affairs in a Dominion as is held by His Majesty the King in Great Britain. He should, therefore, cease to be the formal official channel of communication between the British and Dominion Governments, who should communicate with one another direct.

The Cabinet.—The Act of Union made provision for an Executive Council of ten ministers. The first ministry after Union included, in addition, a minister without portfolio. In 1925, provision was made for the appointment of an eleventh member of the Cabinet. The number

of portfolios has varied from time to time, but at present the eleven ministers are responsible for the following fifteen departments of State :—

Department of the Prime Minister and of External Affairs.
Department of Justice.
Department of Lands.
Department of Mines and Industries.
Department of Public Health.
Department of the Interior.
Department of Finance.
Department of Agriculture (with Irrigation and Forestry).
Department of Education.
Department of Defence.
Department of Railways and Harbours.
Department of Public Works.
Department of Labour.
Department of Posts and Telegraphs.
Department of Native Affairs.

The Legislature.—The legislative power is vested in two houses, the Senate and the House of Assembly.

The Senate is charged with the usual revising functions on legislation originated in the Lower House, but the Senate may also originate legislation. Bills appropriating revenue or money or imposing taxation must be originated in the Assembly, and the Senate has only the power of acceptance or rejection of such legislation, which it may not amend. It may likewise not amend any Bills so as to increase any proposed charges or burden on the people.

The Senate consists of forty members. Eight of these are elected for each Province, under the system of Proportional Representation with the single transferable vote, by a college consisting of the elected members of the House of Assembly and the Provincial Council. The

remaining eight are appointed by the Governor-General-in-Council. An interesting provision is that by which four of the latter should be persons " selected on the ground mainly of their thorough acquaintance, by reason of their official experience or otherwise, with the reasonable wants and wishes of the coloured races in South Africa." Senators hold their seats for ten years unless the Senate is dissolved in the meantime.

The House of Assembly consists of a variable number of members elected under the suffrage laws of each province in one-member constituencies. At the date of Union it was considered necessary to grant the two smaller provinces, Natal and the Orange Free State, a somewhat larger representation than their European populations would have justified. They were, however, precluded from obtaining additional representation until their population increased sufficiently to justify this. A quinquennial census of population and a subsequent redistribution of seats by three judges of the Supreme Court was provided for in the Act of Union. After the Census of 1926, the Orange Free State obtained one additional seat, but Natal still retains its original number of seventeen members. The Provinces will be represented as follows after the General Election of 1929 :—

Cape Province	58	members.
Transvaal	55	,,
Orange Free State	18	,,
Natal	17	,,
Union	148	members.

The Act of Union provides that after the membership reaches 150 for the four original provinces, the number shall not be increased unless Parliament otherwise decides, and the proportion between the number of male European adults and members of the House of Assembly shall, as far as possible, be the same in each province.

The Electorate.—The problem of establishing a Union Franchise was one which the National Convention failed to solve. The compromise was, therefore, adopted of allowing the electoral laws of each province to remain in force. The result of this compromise was that non-Europeans continue to enjoy franchise rights in the Cape Province, while colour is a bar to electoral rights in the other Provinces. It is indeed not an absolute bar in Natal, but the number of coloured voters is negligible, and the list has not been added to since Union. In the three northern provinces the franchise can, therefore, be described, with substantial accuracy, as a male adult European franchise. In the Cape Province, on the other hand, the franchise is based on the formula "equal rights for all civilized men." "Civilized" is held by the law to comprise (1) ability to sign one's name and write one's address and occupation; (2) occupation of premises of the capital value of £75 or receipt of salary or wages of not less than £50 per annum. These amounts were determined in 1892. Since then there has been a substantial drop in the purchasing power of the sovereign. The earliest indexes available, those for retail prices in 1895, show a rise in Cape Town from 808 in 1895 to 1,291 in 1928. The property and income qualifications have, therefore, dropped by 37·5 per cent., thus making it considerably easier to become enfranchised than was originally intended.

Repeated attempts have been made to enfranchise women. The question is, however, complicated by the problem of the non-European franchise. All parties are now committed to support a measure of this kind in the next Parliament.

The Judicature.—The South Africa Act constituted a Supreme Court of South Africa. This court consists of an Appellate Division presided over by the Chief Justice, with four provincial divisions each presided over by a

Judge President, and local divisions for the Cape Eastern Districts, Griqualand West and the Witwatersrand. The Circuit Courts of the various provinces are also local divisions of the Supreme Court.

In addition to these superior courts, there is the Native High Court of Natal, which tries serious criminal cases brought against natives.

There is no appeal from the Appellate Division to the King-in-Council, but the King-in-Council retains the right to grant special leave to lodge such an appeal.

Functions of Government Departments.—Lack of space precludes a detailed description of the functions of Government departments, but the following points may be noted. The Meteorological Office and the Hydrographic Survey are under the Department of Irrigation. Higher education comprises university and technical education, and the Department deals also with industrial schools, child welfare and protection of children. The Provincial Councils are responsible for all other education including the training of teachers, except where such training is part of a university course. The High Commissioner's Office in London is a division of the Department of Finance. Mental hospitals are in charge of the Department of the Interior, leper asylums and military hospitals of Public Health, other hospitals of the Provincial authorities. The Interior Department also deals with the important subject of Indian affairs. The Lands Department controls land survey and maintains, through the Registrars of Deeds, the very complete system of land registration which the Union possesses. The Department of Mines and Industries has among its functions the Geological Survey, the Research Grant Board and the Electricity Control Board, and shares Fisheries with the Provincial Administrations.

The audit of public expenditure is vested in the Controller and Auditor General, a parliamentary officer holding a position of independence similar to that of a

Judge of the Supreme Court. He reports annually to Parliament on the accounts both of the Central Government and of the Railways. Matters on which he reports are subsequently examined in detail by the Committee on Public Accounts of the House of Assembly.

The Public Service.—A body of three Commissioners, styled the Public Service Commission, makes recommendations to the Government as to staffing and personnel of government departments.

The Public Service is divided into the following divisions :—

(*a*) *The Administrative Division.*—The principal posts included in this division are those of secretary and under-secretary of a department, the higher clerks, provincial secretaries and auditors, and magistrates.

(*b*) *The Clerical Division.*—This includes all the lower clerks.

(*c*) *The Professional Division.*—This includes posts held by persons with definite technical or professional qualifications, such as engineers, medical men, veterinarians, astronomers, chemists, botanists, geologists, etc.

(*d*) *The General Division.*—This includes miscellaneous posts not of a clerical grade, such as storekeepers, nurses, watchmen, dipping inspectors, messengers, etc.

(*e*) *The Services.*—This includes the permanent defence force, the police force and subordinate officers of the prisons department.

State Finance—*Revenue.*—The tradition which the Union inherited was very strongly one of indirect taxation, and while, with the advent of the income tax, direct taxation has increased in importance, more than

one-third of the revenue is still derived from Customs and Excise. During the year 1927-28, the following were the principal sources of revenue of the central government :—

Source.	Amount.	Percentage of Total.
Customs and Excise	£10,953,057	36·40
Income Tax and Death Duties	7,642,104	25·39
Post Office	3,770,300	12·53
Public Estate	2,921,162	9·71
Interest	1,662,007	5·52
Taxation of Natives	995,968	3·31
Miscellaneous	2,149,406	7·14
Total	£30,094,004	

In regard to the chief source of revenue, it should be remarked that the tariff which was adopted in 1925 aims at protection of South African industries. It, however, contains, in addition, a large number of purely revenue duties. Many of these are on articles of daily use. The rate is 20 per cent. *ad valorem* in the majority of cases. In spite of the adoption of the protective tariff in 1925, the revenue from Customs duties has shown a steady increase annually.

The income tax is divided into a normal tax, payable on all incomes, and a super tax, payable on incomes in excess of £2,500, subject in both cases to certain abatements. The primary abatement on normal tax is £300 for single, and £400 for married persons. There are also abatements for children (£60 per head), other dependents (£30 per head), insurance premiums (maximum £50) and friendly society contributions (maximum £10). There are provisions for reducing the amounts of these abatements as income increases.

The personal rate for normal tax is one shilling and as many two-thousandths of one penny as there are

pounds in the taxable amount, with a maximum of two shillings in the £. For incomes of companies, the system of collection at the source is applied, the rate being three shillings in the case of gold and diamond mining companies, and two shillings and sixpence in the case of other companies.

The rate for super tax is one shilling and as many five-hundredths of a penny as there are pounds in the taxable amount, with a maximum of five shillings in the pound. Incomes derived from certain sources are exempt, the most important being receipts of building and friendly societies and receipts (other than income from investments) of mutual life insurance societies and companies dealing only with their own members. As taxation at the source applies in the case of company dividends, these are not included in the individual assessment for normal tax. For super tax, however, they are included.

Estate duties are graduated according to value, the rate being ½ per cent. on the smallest estates and rising to 17 per cent. on those in excess of £75,000.

Succession duties are graded according to the degree of relationship of successor to predecessor, the rate varying from 2 to 10 per cent.

The Post Office revenue represents the gross income, but against that has, of course, to be placed the operating expenditure. For several years past there has been a profit on the running of the State posts, telegraphs and telephones.

Public estate is still an important factor in the public finance of the Union. The Government has extensive rights in regard to gold, diamonds and platinum. A certain amount of revenue is derived from Crown land, and from the Guano Islands off the coast. A differentiation is made between proceeds of public estate, which must be regarded as amortization, *e.g.*, in the case of wasting mineral assets, and those which may be regarded as recurring. The former are credited to loan funds and

used for capital purposes, the latter to revenue. The figures in the above table represent only the amount credited to revenue.

The item " Interest " represents largely the proceeds of loans raised by the Central Government for the Provinces, the Land Bank, housing and purchase of land, the universities and similar State-aided institutions. The interest is contributed by them to the Consolidated Revenue Fund. Interest on railway capital is paid direct from the Railways and Harbours Fund to the Public Debt Commissioners. The item " Taxation of Natives " refers to direct taxation and does not include such native taxes as are credited to the revenue of the provinces.

Expenditure.—The principal branches of expenditure during 1927-28, and the extent of their drain on the exchequer, are shown in the following table :—

Expenditure.	Amount.	Per cent. of Total Expenditure.	Per cent. of Total Revenue.
Provincial Subsidies ..	£5,462,840	19·30	18·15
Law, Order and Protection	5,533,700	19·55	18·39
Post Office	2,982,710	10·54	9·91
Pensions	2,375,972	8·40	7·89
Lands and Agriculture ..	1,566,515	5·53	5·21
Public Health	945,287	3·34	3·14
Higher Education ..	789,465	2·79	2·62
Public Works	921,158	3·25	3·06
Mines, Labour, etc. ..	619,340	2·19	2·06
Native Affairs	329,548	1·16	1·10
General Government ..	1,578,707	5·58	5·25
Public Debt	5,198,366	18·37	17·27
TOTAL	£28,303,608	100·00	—
Surplus	1,790,396	—	5·95
TOTAL	£30,094,004	—	100·00

The State Railways.—Before Union, a considerable revenue had been derived annually from the State Railways. It was felt by the National Convention that the use of the railways as a means to swell the exchequer involved differential taxation of the interior. The desirability of excluding political motives in the operation, and new construction, of the railways was also strongly felt. It was consequently decided to introduce for the railways a separate administration, apart from the public service. The Minister of Railways is assisted by a railway board, which reports on proposals for the construction of new railway lines or harbours. If Parliament authorizes the construction of a railway line not recommended by the board, the loss, if any, is to be made good by the Consolidated Revenue Fund. The railway revenue is paid into a separate fund, distinct from the Consolidated Revenue Fund.

The South Africa Act laid down the cardinal principle that " the railways, ports and harbours shall be administered on business principles, due regard being had to agricultural and industrial development within the Union, and promotion by cheap transport of the settlement of an agricultural and industrial population in the inland portions of all provinces."

As the budgets of the colonies before Union had depended to some extent on railway earnings, the constitution allowed four years for the readjustment of rates. During this period, the sum of £3,179,000 was paid from railway revenue into the Consolidated Revenue Fund.

Since 1914, both profits and losses have been experienced, the latter years of the war and the period immediately following being responsible for a considerable accumulated deficit. This has, however, now been overtaken and a small surplus established.

The Provinces.—The four states which combined in 1910 to form the Union thereafter became constituent

provinces thereof. The constitution provided for the creation of the following machinery for the administration of each province :—

(1) An Administrator appointed by the Governor-General-in-Council and holding office for five years.

(2) An Executive Committee consisting of the Administrator and four members elected by the Provincial Council by the system of proportional representation with the single transferable vote.

(3) A Provincial Council, elected by persons qualified to vote according to the electoral laws of the Province. In the two larger provinces, the constituencies are identical with those for the House of Assembly. The Orange Free State and Natal were, for this purpose, delimited into 25 constituencies each.

The Provincial Councils may legislate by passing ordinances on certain matters specially reserved to them in the constitution, the most important of which are :—

(1) Education other than higher education.
(2) Hospitals and charitable institutions.
(3) Local Governmental Institutions (Municipalities, Divisional Councils, Health Committees, etc.).
(4) Roads and Bridges.
(5) Preservation of Game and Fish.
(6) Eradication of Vermin and Noxious Weeds.
(7) Regulation of Shop Hours and Public Entertainments.

Provincial Revenues.—As a considerable revenue was derived before Union from duties levied by the Customs Union, and as the perpetuation of inter-provincial free trade was obviously one of the advantages that would accrue from the Union of the Colonies, the question of provincial revenue presented a problem of some difficulty

During the first three years of Union, the whole of the revenue of the Provinces was supplied by the Union Government. After investigation by a Financial Relations Commission, the question was regulated by the Financial Relations Act, 1912, which provided for the payment by the Union Government of one-half the ordinary expenditure of the provinces, the other half to be raised by certain licences and taxes. The power of taxation was limited to " direct taxation," which term gave rise to a considerable amount of litigation. Moreover, the principle of the £ for £ grant was found to be unsound. A new basis was, therefore, adopted in 1925. Under this the Union Government subsidy was based on the number of European children attending school in each province. The proceeds of certain licences and fees were also given to the Provincial exchequer and the power of taxation was more accurately defined. The principal sources of revenue from taxation now existing in the various provinces are motor vehicles, amusements, horse racing and sales by auction. Limited power of taxation on incomes is also granted to the provinces.

Local Government.—While in many European countries local governmental institutions may be said to antedate the central government, the reverse is the position in a new country like South Africa. The local authority has, therefore, invariably been a creation of the central authority. The form of local authority, introduced by the Dutch East India Company in the Court of Landdrost en Heemraden, dates back to the 17th century. In the 19th century, legislation provided for the creation of various new types of local authority. An act providing for the creation of municipal councils was passed by the Cape legislature in 1836, and another for the creation of Divisional Councils in 1855. Various forms of local authority were created in the other provinces. After Union, legislation in regard to local affairs became a

function of the Provincial Councils. The various forms of local authority now in existence in the provinces are as follows :—

Cape Province.—Divisional Councils, Municipal Councils, Village Management Boards, Local Boards and Local Areas.

Natal.—Municipal or Borough Councils, Local Boards, Villages and Local Administration and Health Boards.

Orange Free State.—Municipalities and Village Management Boards.

Transvaal.—Town Councils, Village Councils, Health Committees.

Municipal Finance.—Municipalities in South Africa raise a considerable portion of their revenue from assessment rates on immovable property. Provision exists for rating on site value, and certain municipalities have adopted the principle of relying largely on site value for rating purposes. The majority of South African municipalities carry on their own public utility services, such as water supply, light, tramways and buses, abattoirs, sewage, sanitary services, etc. Apart from these a certain measure of municipal trading is in existence, such as the brewing and sale of native beer, the maintenance of baths and bathing pavilions, the sale of plants and manure, and housing. An exception to the State monopoly of public telephones exists in the Durban municipal telephone system.

IV.

EDUCATION:
UNIVERSITIES AND TECHNICAL COLLEGES.

By the Union Education Department.

Historical.—Two hundred and seventy-seven years ago van Riebeeck arrived at the Cape of Good Hope and founded the first European settlement.

Into this short span of years have been compressed varying vicissitudes, experiences and developments, which in the older countries extended over long eras—ever-widening explorations and settlements involving the conquest of barbaric tribes, the peopling of the land, the establishment of law and order, the development of agriculture, stock-raising and mining, the opening up of communications over vast distances, the provision of the means of education, the progress of government from a state of subordination under the Dutch East India Company to complete self-government and independent status in the British Commonwealth of Nations.

During the pioneering stages of our development, which cover about two centuries, conditions were not conducive to the fostering of education. Yet, throughout the varying fortunes of our struggling citizens, there have always been more or less sustained efforts to make some provision for education. For longer than a century, these did not result in much more than a number of parochial schools of a very elementary type, but with the advent of the 19th century, more ambitious efforts, initiated mainly by churches and men of vision, can be recorded.

Before the close of the 18th century, a Latin school of the gymnasium type had been founded in Capetown. In 1821, arrangements were made for qualified teachers to be engaged in Scotland for classical schools at Caledon, Stellenbosch, Uitenhage, Tulbagh and Graaff-Reinet. The South African College, Capetown, was opened in 1829; thus its successor, the University of Capetown, celebrates its centenary this year. In 1842, a normal training college for teachers, which owed its origin to the Dutch Reformed Church, was established in Capetown. The Diocesan College at Rondebosch, a Church of England foundation, was founded in 1849. A distinct stimulus to educational effort in and beyond the confines of the Cape Colony was derived from the influence of Sir George Grey, who became Governor of the Cape in 1854, and simultaneously representative government was introduced in that colony. To this period we owe the establishment of St. Andrew's College at Grahamstown, an institution of a character similar to that at Rondebosch, the Grey College at Bloemfontein and the Grey Institute at Port Elizabeth. Under the Colonial Education Act of 1865, the public school at Stellenbosch was reorganized as the Stellenbosch Gymnasium. The Huguenot Seminary at Wellington was founded in January, 1874, by the Rev. Andrew Murray, high schools of a sort were opened in Pietermaritzburg and Durban in the "sixties", and in 1893 the Staats-Gymnasium, modelled on the gymnasia of Holland, and the Staats-Meisjesschool were opened at Pretoria. Other institutions of this type, which served a useful purpose in former days, were the Graaff-Reinet College (founded 1860) and the Gill College at Somerset East (founded 1869).

Further reference to institutions which are not included under the title of this chapter will not be made, and the further development of European and non-European primary and secondary education will not be dealt with, but reference must be made to the establish-

ment of the Lovedale College for natives in 1841. From this institution, the result of missionary enterprise, the South African Native College, Fort Hare, which makes provision for the higher education of non-Europeans, may be said to have developed.

A great step in advance, in the work of higher education, was taken by the statutory provision made in 1858 for the establishment of a Board of Public examiners, the embryo form of the future University of the Cape of Good Hope. This University was established in 1873 by Act of the Colonial Parliament, on lines broadly resembling the unmodified University of London. Its main functions were to prescribe courses of study in the various branches of higher education, both general and professional, to test the acquirements of all students who entered their names and paid their fees, to grant formal recognition of the degree of proficiency attained, as evidenced by such tests, and to award such premia for distinctive merit as might be placed at its disposal for that purpose.

The Higher Education Act, 1874, a corollary of the University Act of 1873, provided for the establishment or enlargement of Arts Departments at the more important centres where the teaching work of the University could be carried on. Three colleges were recognized under the Act, practically from its promulgation: the South African College at Capetown, the Gymnasium at Stellenbosch, and the Diocesan College at Rondebosch. The Huguenot College for women was recognized in 1898, and the Rhodes University College in 1903 took the place previously held by St. Andrew's College, Grahamstown.

When the British Association held its meeting in South Africa in 1905, the problem confronting the University was to make the union of the University and the Colleges much closer and more efficient, and it was generally felt that the time was approaching for a further

advance in University organization. An inter-Colonial Conference, to discuss the lines of development, was held at Capetown in 1908, but the whole position was radically changed as a result of the passing of the South Africa Act (1909) and of the offer to the Union Government, through Mr. Otto Beit and Sir Julius Wernher, of a sum of £500,000 for the establishment of a national university on the Groote Schuur estate near Capetown. A Bill, known as the University of South Africa Bill, designed to give effect to this proposal, was introduced into Parliament during the session of 1913. The measure, however, met with much criticism, and the ultimate solution as embodied in the University legislation passed in 1916, was found in the establishment of three Universities in the place of the University of the Cape of Good Hope.

The University of South Africa from 2nd April, 1918, became the legal successor of the University of the Cape of Good Hope, with headquarters at Pretoria. It embraces the following constituent colleges: Grey University College, Bloemfontein (incorporated 1910); Huguenot University College, Wellington (incorporated 1907); Natal University College, Pietermaritzburg (founded and incorporated 1909); Rhodes University College, Grahamstown (founded 1903 and incorporated 1904); University College, Potchefstroom (founded 1905 and incorporated 1921); and the Transvaal University College, Pretoria (founded and incorporated 1908). The South African School of Mines and Technology (founded and incorporated 1903), was renamed the University College, Johannesburg, on 20th September, 1920, and was a constituent college of the University of South Africa until 1st March, 1922, when it was incorporated as the University of the Witwatersrand, Johannesburg. From 2nd April, 1918, the Victoria College, Stellenbosch (formerly the Stellenbosch Gymnasium) and the South

African College, Capetown, were incorporated as independent Universities, known respectively as the University of Stellenbosch and the University of Capetown.

University Institutions : University of South Africa.—As stated above, the University of South Africa embraces six constituent colleges. At each college there is a Governing Council responsible for general administration and a College Senate, consisting entirely, or mainly, of the professors on the staff, which controls academic matters and discipline. The government and executive authority of the University are vested in a Council, consisting of eight members appointed by the Governor-General, four elected by Convocation and one member appointed by the Council and one by the Senate of each constituent college.

The colleges all prepare students for degrees and diplomas in science, arts and education. In addition to this they offer facilities for training in various other specialized directions, to which reference will be made.

They are in general largely residential institutions, and possess houses and dining-halls for students.

(i) *Grey University College, Bloemfontein*.—The College was founded in 1855 by a generous gift from Sir George Grey, but it was not until 1904 that the classes were organized in such a way as to permit of the separate constitution of a University College, which took place in 1907. The erection of the college buildings was completed in 1909, and in 1910 the University College was incorporated by statute. The work undertaken comprises the usual academic courses and special courses in survey, commerce and law.

(ii) *Huguenot University College*.—The Huguenot College has grown out of the Huguenot Seminary, which was founded in January, 1874, by the Rev. Andrew Murray, D.D. Dr. Murray had been greatly interested in the life of Mary Lyon and her educational work in

America, and he determined to establish an institution similar to Mount Holyoke Seminary, which should be a Christian educational home for the daughters of South Africa. Miss A. P. Ferguson and Miss A. E. Bliss came from Mount Holyoke, Massachusetts, U.S.A., to become Principal and Vice-Principal of the Huguenot Seminary. It was recognized as a College in 1898, and incorporated by Act of Parliament in 1907. In 1918, as the Huguenot University College, it became one of the constituent colleges of the University of South Africa. The College offers special facilities for the study of domestic science and horticulture.

(iii) *Rhodes University College* was established in 1904, when it took over the college department of St. Andrew's College School, which had carried on university work in Grahamstown since 1878 with state-aided lecturers, who were transferred to the Rhodes College. A sum of £50,000 was gifted by the Rhodes Trustees towards the establishment of the College, augmented by £10,000 raised locally, and also by a bequest of £25,000 from the late Alfred Beit and £5,000 from the De Beers Company. Plans for the complete college building scheme have been prepared, and are being carried out as funds permit. Courses are given in the usual academic subjects and in law, commerce and fine arts. The Grahamstown School of Art has been taken over as a department of the College.

(iv) *Transvaal University College*.—In February, 1908, University classes were established at Pretoria in accordance with the recommendations of the Transvaal Higher Education Commission (1907), to provide instruction in Arts and Science for the higher examinations of the University of the Cape of Good Hope. These classes were organized in the first instance by the Transvaal Education Department, but as soon as the necessary arrangements were completed, were placed under the

control of the Council of the Transvaal University College, formerly the Johannesburg Technical Institute. The Council of that institution was reorganized, seven of the old members being reappointed to represent Johannesburg, in which centre the Department of Applied Science was stationed in terms of the Commission's recommendations, while seven new members were added to represent Pretoria.

A definite landmark in the history of the institution was reached towards the end of 1909, when the Transvaal Parliament, in its last session, voted the sum of £50,000 for the erection of permanent College buildings on the fine site on the town-lands to the east of Pretoria, set aside by the Municipality of Pretoria, and on 3rd August, 1910, the foundation-stone of the main building was laid by His Excellency the Governor-General. In the meantime an Act of Incorporation had been obtained, establishing the Transvaal University College, Pretoria, as a separate institution distinct from the South African School of Mines and Technology, Johannesburg, and this Act received the assent of the Governor-General on April 27th, 1910.

In 1919 the Government decided to establish a College of Veterinary Science under the headship of Sir Arnold Theiler, the new institution to be a Faculty of the Transvaal University College, the first two years of the course being given at the College, and the remaining three at the Government Veterinary Research Laboratories at Onderstepoort.

The specialized training which the college offers comprises courses in agriculture, veterinary science, domestic science, law, divinity, commerce and public administration.

This institution is the largest constituent college of the University of South Africa. It has an enrolment of about 800 students. About 45 per cent. of these are of

the extra-mural type, *i.e.*, they are in employment and follow part-time classes. Special provision was made for them by the erection of a building in the middle of the town in 1926 at a cost of £13,000.

(v) *Natal University College.*—In February, 1908, an Inter-State Conference on University Education in South Africa was held in Capetown, and passed resolutions which were subsequently considered by the various legislatures, with the result that the Natal Government was induced to make immediate provision for the Province's higher educational needs, and it was decided that a University college should be established on a suitable site in Pietermaritzburg. The Corporation of Pietermaritzburg offered a site at Scottsville, extending to forty acres. Plans were selected from competitive designs, and the project was practically accomplished on 11th December, 1909, when the Act of Incorporation (No. 18, 1909) was promulgated by the Governor of Natal. Temporary accommodation had to be used pending the erection of the University College Buildings, which were publicly opened on 9th August, 1912.

By an important arrangement completed in 1922, the Natal University College has included within the scope of its work the departments of Engineering, Commerce and Fine Arts, at the Natal Technical College, Durban, with corresponding provision for the inclusion of the professors and lecturers in these departments in the University College Senate, and for representation of the University College Council on the Council of the Natal Technical College.

Courses in law and education as well as the usual academic subjects are given in Pietermaritzburg, while the university section of the Technical College in Durban trains for degrees and diplomas in commerce, engineering and fine art.

(vi) *Potchefstroom University College*, which developed out of the literary department of the Theological School of a small off-shoot of the Dutch Reformed Church called the " Gereformeerde Kerk van Suidafrika," was founded on 29th November, 1869, at Burghersdorp, Cape Province. In February, 1905, this school was transferred to Potchefstroom. In April, 1919, a government subsidy was granted to its literary department, and a complete separation between the literary and theological departments took place. The College was placed under the management of its own council under the present name. In June, 1921, the Potchefstroom University College (Private) Act was passed by Parliament. On 6th July, 1921, it was incorporated, by proclamation, as a constituent college of the University of South Africa. In addition to the courses which are common to all the constituent colleges of the University of South Africa, Potchefstroom offers training for degrees in divinity.

University of Capetown.—The University of Capetown, with which is incorporated the South African College, was created by Act No. 14 of 1916, and came into legal existence on 2nd April, 1918, when the munificent bequests of Wernher and Beit, amounting in all to £500,000 were handed over to the Council. A history of the South African College from the earliest days, which had been taken in hand in 1916, on the initiative of the College Senate, was written by Professor W. Ritchie and published in two volumes in 1918.

Classes were opened on the 1st of October, 1829, and the students were subsequently entered for the examinations of the Cape Board of Examiners, and from 1873 for the examinations of the Cape University. For many years the greater number of the students prepared for the matriculation examination, and only a few proceeded to the degree courses. In 1886 women students were first admitted to the college. In 1895, classes were

opened for mining engineers, and by 1900 the college had made such developments in its higher work that it was decided to confine it entirely to University teaching, and the matriculation classes were transferred to the College School.

In 1902 an extensive forward movement was undertaken on the initiative of the Senate. A sum of £40,000 was collected from past students and friends, and substantial financial assistance was given by the City Council. Additional property was acquired, new buildings erected, and several new chairs established. Among other developments, courses for medical students and diploma courses in civil, mechanical and electrical engineering were inaugurated in 1904 ; in 1910 post-graduate courses for the training of teachers were started in collaboration with the Normal College. In 1911, the University classes of the Diocesan College, Rondebosch, were, by arrangement, transferred to the College.

In that same year the Hiddingh Hall was opened, and the Bolus Herbarium and Library, and other valuable benefactions, became available under the will of the late Dr. H. Bolus. This is only one of numerous bequests and donations received by the college since its foundation, and more especially in the last twenty-five years of its history. In 1916 the Normal College was amalgamated with the education department of the college.

When, in 1918, the South African College was transferred into the University of Capetown, it severed its connection with the University of South Africa, and became entitled to examine its own students and grant degrees.

The first block of the new buildings for the University at Groote Schuur (in terms of its Act of Incorporation) was opened in 1926. New residences to accommodate men and women students have been erected, and the new buildings for the various departments are nearing com-

pletion. It is intended to complete the new University buildings at a cost of £1,250,000 by 1930. Towards this the Government has contributed a loan of £750,000. Close to the main building a hospital with 800 beds has been erected, which will serve as a clinic for the Medical School.

With the transfer of the University of Capetown to its new habitation on the slopes of Table Mountain at Groote Schuur, another chapter in its long history has been opened. It is magnificently situated in historic and inspiring surroundings. More even than in the past, it will be able to offer facilities for advanced scientific work in many directions. It has faculties of science, arts, education, commerce, law, medicine, engineering and fine art. In this connection reference may be made to its professional and specialized branches of study, *e.g.*, its Schools of Medicine, African Life and Languages and Music, and the Michaelis School of Fine Art, which was incorporated with it in 1925.

The University is the oldest and largest institution of its kind in the country.

The University of Stellenbosch.—Stellenbosch is the second oldest town in the Union, and with the establishment of the second congregation of the Dutch Reformed Church in 1685, regular school instruction commenced there. Its reputation as an educational centre was enhanced by the establishment in 1859 of the Theological Seminary of the Dutch Reformed Church and the reorganization, under the Education Act (Cape) of 1865, of the public school as the Stellenbosch Gymnasium which prepared for the admission examination of the Theological Seminary, and for the certificates in literature and science of the Cape Board of Examiners. A college building was erected in 1880 to commemorate the bicentenary of the founding of the town (1679). In 1881, the Stellenbosch College was constituted, but the secondary school, though separated from the College, remained under the

College Council. In 1887, the College was renamed Victoria College. In 1899, all pre-matriculation work was removed from the College to the School.

The solution of the thorny problem of the reform of higher education proposed by the University legislation of 1916 was made possible so far as Stellenbosch was concerned by the benefactions of the late Jan Marais, of Coetzenburg, who left £100,000 to the new University. On 2nd April, 1918, the Victoria College became the University of Stellenbosch, and in addition to fulfilling its previous functions, it became entitled to examine its own students and grant degrees. Provision is made for courses leading to degrees and diplomas in the faculties of arts, science, agriculture (including domestic science), law, theology, education and commerce. Attached to the Faculty of Arts is a department of Bantu Studies. Facilities for research, including well-equipped laboratories and a university library, have been made available. A special feature of this University is its Faculty of Agriculture. By Act No. 45 of 1926, this Faculty and the Elsenburg School of Agriculture were amalgamated. The University is mainly a residential institution and has many hostels for men and women students.

The University of the Witwatersrand, Johannesburg.— The growth of higher education on the Witwatersrand may be traced back to the inauguration in 1894 by the Government of the Cape of Good Hope of a scheme for the training of mining engineers. This resulted, in 1896, in the establishment of a School of Mines at Kimberley. After the close of the South African war it was felt that the Witwatersrand offered the greatest advantages for training in mining and technology, and the Transvaal Technical Institute was formally opened in Johannesburg on 29th March, 1904, the staff at Kimberley being transferred to this new institution. It very soon also established classes in arts, pure science and law, and

Plate 9]

UNIVERSITY OF CAPETOWN.

under various names, *e.g.*, the Transvaal University College, the South African School of Mines and Technology and the University College, Johannesburg, which marked stages in its development, it continued to grow. For a short period the two university institutions in Johannesburg and Pretoria were combined under one Council, but this arrangement was not found satisfactory. In 1917, the South African School of Mines and Technology was made a constituent college of the University of South Africa, and in 1922 this institution, which had meanwhile assumed another name, was transformed by an Act of the Union Parliament (1921) into the University of the Witwatersrand.

Many individual citizens have contributed liberally to the funds of the University. One effort resulted in more than £200,000 being collected by public subscription. A bequest of £200,000 by the Executors of the estate of the late Mr. Alfred Beit enabled the institution to enter a period of rapid expansion. Much of its success is also due to the generous support of the Reef Municipalities. The Johannesburg Municipality, in addition to a grant of valuable land, donated £25,000 for capital purposes, and continues to give £10,000 per annum towards current requirements. Due acknowledgment should also be made of the generous grants made annually by the Witwatersrand Council of Education, which has throughout its existence been the constant friend of many educational efforts on the Witwatersrand, its grants for higher education totalling close upon £100,000. A grant of land adjoining the gift of the Johannesburg Municipality was made by the Transvaal Consolidated Land and Exploration Company, Ltd. On this combined site at Milner Park the University Buildings have been, and are being, erected. They are on a ridge overlooking Johannesburg, not far from the centre of the city, and command a striking view to the north.

In this, the youngest and second largest University of the Union, provision is made for courses leading to degrees and diplomas in the faculties of arts (including music, education and Bantu studies), science, medicine (including dental surgery and public health), engineering (including architecture), commerce and law.

Finance and General.—The system under which grants-in-aid and loans are given to the Universities and University Colleges is based on regulations framed under Section 12 of Act No. 20 of 1917. The institutions receive annual block grants from the Government. These are automatically increased up to a maximum originally of 10 per cent., and since 1928 of 5 per cent., from year to year, if an institution by virtue of the growth of its own revenue can " earn " an increase of grant under the regulations. As a result of the report of the University Commission of 1928, these automatic increases may, however, be stopped, and an institution will then have to approach the Minister of Education and the Government for special consideration, if it wishes its subsidy to be raised. The power of the Minister to direct the development of university education would, under a policy of stabilization of grants, become even more effective. The existing statutory provision which renders it impossible for a university institution to begin any new faculty, department, professorship or lectureship without his sanction already gives him a large measure of control.

The following tables give some details as regards University revenue, subsidies, assets, student-enrolment and staffs :—

REVENUE AND VALUE OF ASSETS OF UNIVERSITIES AND UNIVERSITY COLLEGES IN 1927:—

University or University College.	Government Grant.	Fees.	Other Revenue.	Total.	Value of Assets.
	£	£	£	£	£
Capetown ..	84,698	48,017	39,356	172,071	1,748,466
Stellenbosch ..	46,163	24,556	12,201	82,920	598,082
Witwatersrand	84,364	43,406	34,577	162,347	741,297
South Africa ..	2,510	23,211	14,066	39,787	88,118
Grey	19,092	7,803	2,050	28,945	130,998
Huguenot ..	8,188	2,040	1,904	12,132	58,974
Natal	14,004	4,229	2,004	20,237	103,924
Potchefstroom	9,943	3,125	2,606	15,674	21,805
Rhodes ..	26,173	12,166	14,450	52,789	254,093
Transvaal ..	37,567	15,611	4,454	57,632	343,194
Total ..	332,702	184,164	127,668	644,534	4,088,951

RETURN OF TEACHING STAFFS AND STUDENTS DURING THE HALF-YEAR ENDED ON 31ST DECEMBER, 1928:—

University or University College.	Teaching Staff.			Students.		
	Professors.	Lecturers, etc.	Total.	Full Time.	Part Time.	Total.
Capetown ..	46	156	202	1,309	474	1,783
Stellenbosch .	39	54	93	1,012	98	1,110
Witwatersrand	37	158	195	1,310	166	1,476
South Africa..	—	—	—	1,021	—	1,021*
Grey	13	23	36	280	35	315
Huguenot ..	7	9	16	87	1	88
Natal ..	15	30	45	217	42	259
Potchefstroom	10	11	21	201	3	204
Rhodes ..	17	21	38	399	60	459
Transvaal ..	43	56	99	442	334	776
Total ..	227	518	745	6,278	1,213	7,491

*External Students.

It may be noted that of the 7,491 students, 5,230 were men and 2,261 were women.

In 1927 there were, apart from external students of the University of South Africa, 5,808 matriculated students in the university institutions to a total European population of 1,670,000, that is, 3·47 per thousand against 1·02 per thousand in 1911. In 1928 the number of matriculated students (including 848 matriculated, external students of the University of South Africa) was 6,577.

Technical Education.—When the Union was formed, the Union Parliament assumed the control of higher education, and delegated to the four Provincial Councils "education other than higher". The inability of the Provincial Administrations to bear the increasing burden of providing facilities for industrial and technical training led to the Union Government taking over this branch of education in 1925. There are now two types of vocational institutions under the Union Department of Education, namely, Vocational Schools and Technical Colleges. In this chapter reference will be made only to the latter, of which there are eight in the Union, and their statutory basis is Act 30 of 1923. They are in various respects, as the recent University Commission observes, "formed in the image of University Institutions", being autonomous institutions under the control of Councils and Boards of Studies, and subsidized by the Government under regulations which are very similar to those in force for Universities. The main difference on the financial side lies herein, that the Technical Colleges are more liberally subsidized, receiving up to 75 per cent. of their revenue from the State. Other differences are these: their admission standard is generally the completion of the primary school course; the bulk of their work consists of part-time classes, and is below matriculation standard; and not only must all new extensions receive the sanction of the Minister of Education, but also all certificates issued by technical colleges.

(*i*) *Natal Technical College.*—The first record of anything of the nature of technical classes for engineers and builders in South Africa appears to have been at Durban, where classes in Geometry, Machine Drawing and Building Construction were opened in 1884. These classes have been held continuously from that date, the pupils increasing from 16 in 1884 to about 45 in 1907, when the classes were taken over by the newly-formed Durban Technical Institute. The governing body of the Institute assumed the management of the existing evening technical classes of the Natal Education Department, and of the Art School. Later, the classes under the control of the Railway Institute and other similar organizations were added.

In 1919 a full-time diploma course for engineers was started, and also a domestic science department.

In 1922 negotiations with the Natal University College were completed whereby university departments of commerce and engineering were initiated. The College was gazetted as an institution for Higher Education under Act No. 5 of 1922, and re-named Natal Techncial College. Up to 1922 the College was financed by Natal Provincial Council grants, grants from the Durban Corporation, and various benefactions. In 1923 with the promulgation of the Higher Education Act, No. 30 of 1923, the Union Government assumed control of the College. A Chair of Fine Arts was established in October 1923. In 1927 the new buildings, erected at a cost of £49,000, were officially opened.

(*ii*) *Witwatersrand Technical Institute.*—In the years following the Peace of Vereeniging (1902), and when the Transvaal was a self-governing colony, important progress in vocational education and continuation work was made on the Witwatersrand and in Pretoria. This was due to steps taken by the Witwatersrand Council of Education, the Transvaal Education Department, the

School of Mines and the northern university institutions. This development was continued by these bodies after the Transvaal became a province of the Union of South Africa, and led to the establishment, under various forms of control, of trade and commercial schools and continuation classes for apprentices and other juveniles. As a result of Act 30 of 1923, and the subsequent transfer of all vocational and part-time education to the Union Education Department in 1925, all these services on the Witwatersrand were placed under the Witwatersrand Technical Institute, which was established in 1926.

Its work comprises: commercial schools in Johannesburg, Brakpan, Krugersdorp and Benoni; trades schools for boys in Johannesburg and Benoni; a trades school for girls; a school of domestic science; a school of arts and crafts. In addition there are numerous day and evening part-time classes for apprentices and others in all the Reef towns, and by means of postal courses an attempt has been made to help the ambitious student at outside centres where class facilities are not available.

The Witwatersrand Technical Institute has received the generous support of the Reef Municipalities.

(*iii*) *The Cape Technical College*.—The Cape Technical College owes its inception to the efforts of the South African College authorities, who first instituted evening classes in Capetown. The professors of the College conducted courses—each course usually consisting of ten lectures on special subjects—during the winter months, held examinations at the end of the courses and issued departmental certificates. These classes were, on the whole, well attended; it was felt that there was need for properly organized courses, and in 1907 the Senate of the South African College decided to open regular three years' courses in Electrical and Mechanical Engineering, in addition to the special classes held in previous years. This proved, however, too much of a

strain on the staff of the College, and the Senate decided to ask the Cape School Board to take over the classes. After careful consideration, the Board agreed, and it also took over classes held at the Salt River Railway Works. In 1910 a special annual subsidy from the Cape Education Department was obtained.

The Technical College, as it came to be called, grew rapidly and obtained proper accommodation. The City Council in 1916 gave a site of $1\frac{1}{4}$ acres in Caledon Square, Capetown, and the Cape Provincial Council, in its 1917 session, promised grants to the amount of £40,000 to start a central building. The foundation stone of the new college was laid by H.R.H. Prince Arthur of Connaught on 26th May, 1921. The college was ready for occupation in October, 1922, the official opening ceremony being performed by His Royal Highness on 16th March, 1923.

The College was gazetted as an Institution for Higher Education under Act No. 5 of 1922, and its status was further enhanced by the Higher Education Act of 1923. Under this Act the College became a definite responsibility of the Union Government, and a representative Council was appointed in which its control was vested. Its activities are analogous to those of the Witwatersrand Technical Institute. It provides full and part-time vocational education in many directions notably in technology, engineering, trades, commerce and housecraft. The Cape Technical College makes a special feature of its centre for non-European students in Harrington Street, where courses in commercial and technical subjects and housecraft are conducted. It also conducts correspondence courses in banking and commerce, and, further, supplies the needs of students living beyond the environment of Greater Capetown through class-centres in Somerset West and Simonstown.

The following figures illustrate the growth of technical education in Capetown :—

Year.	No. of individual students enrolled.	Full-time teaching staff.
1915	311	1
1918	552	1
1921	645	3
1923	1,600	15
1927	4,370	137*

*Full-time and part-time.

Equally striking figures could be quoted for the other Technical College centres in the Union.

It has been mainly owing to generous State support that the College has been enabled to extend its functions and accommodation, but it has also received handsome donations. Mr. John Garlick contributed £5,000 to its equipment fund, and from the Sir William Thorne Fund a sum of £4,000 was placed in trust for bursaries. The Capetown Municipal Council, besides providing the site on which the main College building is erected, has annually voted a sum of £1,000 towards its support.

(*iv*) *Other Technical Colleges*.—The technical colleges of Pretoria, East London, Pietermaritzburg, Port Elizabeth and the Orange Free State Technical College in Bloemfontein, have all developed along lines more or less similar to those indicated in the notes on the technical colleges of Durban, the Witwatersrand and Capetown. Thus, the Pretoria Technical College grew out of various Provincial institutions—a trades school for boys opened on 19th January, 1909, a commercial high school, and various part-time classes formerly conducted by the Pretoria Polytechnic; the East London College developed from Railway Technical and School Board continuation classes, and the Port Elizabeth College from a School of Arts and Crafts and certain part-time classes conducted by the local School Board.

Plate 9.] UNIVERSITY OF THE WITWATERSRAND.

The following table gives the revenue, staff and enrolment figures of the various Technical Colleges :—

Technical College.	Revenue : 1927.		Staff : 1928.		Students : 1928.	
	Government Grant. £	Other Revenue. £	Teaching.	Administrative.	Full time.	Part-time and correspondence.
Capetown ..	28,932	16,101	155	17	584	4,178
East London ..	6,800	2,517	38	6	6	718
Natal (Durban)	27,002	14,311	96	14	296	1,720
P. Maritzburg..	5,500	3,563	25	3	53	410
Port Elizabeth	9,000	5,383	53	6	99	984
Pretoria ..	21,300	11,844	148	8	530	1,850
Witwatersrand.	71,800	32,266	470	24	2,047	6,218
Total ..	170,334	85,985	985	78	3,615	16,078

At the end of June, 1926, the total teaching staff numbered 758, administrative staff 38, full-time students 2,541, and part-time students 10,917.

Some General Observations.—In 1928 there were close on 20,000 students receiving instruction through technical colleges, and if this figure is compared with their student enrolment in June, 1926, namely, 13,400, it will be evident that technical education has made very rapid progress since its transfer to Union control. This is largely because the Union Government with its larger financial resources is better able than the Provinces were to subsidize the technical colleges at a rate commensurate with the growing needs which they are supplying. These needs stand in close relation to the rapid industrial development of the Union and to the improved status of workers in industrial and commercial areas which has been brought about by legislation. An

outstanding example of this legislation is the Apprenticeship Act of 1922, which provides, *inter alia*, for the compulsory attendance at continuation classes of apprentices. A very large percentage of the students attending technical colleges are apprentices, and it remains to be seen whether this system of training for industry will in the end prove in every way suitable for the needs of the country, or whether the full-time day trades schools which are also incorporated in the technical colleges will ultimately predominate.

The growth of the technical colleges in another direction, namely, the more advanced type of work which they are attempting, has produced other interesting problems. It will have been noticed that the Natal Technical College, Durban, has been allowed to develop a university section, and other technical colleges also show this inclination. It was felt that South Africa with its small white population has already too many institutions doing, or attempting to do, university work, and one of the main reasons why the University Commission of 1927-28 was appointed, was to lay down a line of demarcation between the functions of universities and those of technical colleges. The Commission in its report stresses the necessity of regarding technical colleges mainly as secondary schools of a special type, and of debarring them in general from doing work of post-matriculation standard. If the spirit of this recommendation is put into effect, the university section of the Natal Technical College, Durban, will have to be re-transferred to the control of the Natal University College, and certain outgrowths of other technical colleges, *e.g.*, in the direction of art departments, will have to be curtailed.

From these few observations it will be clear that definite lines of policy with regard to matters pertaining to higher education are being carefully sought, and that

some important phases of education in South Africa have reached critical stages in their development. This is also true of the university institutions considered apart from technical colleges. It is widely felt that three residential universities and six university colleges are perhaps more than the country requires, and certainly more than it can adequately equip and staff. It was, therefore, also an instruction to the University Commission to suggest a solution for this problem. Its recommendations under this head lie in the direction of debarring the smaller university institutions from attempting to offer specialized or advanced courses for which they are not adequately equipped, and of assisting the larger institutions by special grants to develop their functions in many directions. With this purpose in view, the Commission recommends that the automatic increase of university subsidies shall cease so that additional funds which may be available from year to year may not be frittered away.

A conference of representatives of all the university institutions which met at the beginning of this year, expressed itself as generally in agreement with the findings of the Commission, and suggested that there would be sufficient scope for the smaller university institutions, if the training of all teachers was more definitely relegated to them. As the training of teachers for provincial schools is a matter in which the provincial authorities have a very important voice, a very large issue is hereby raised, and it again becomes clear that hardly any important problem affecting any branch of education in South Africa ever presents itself, the solution of which does not imply a greater degree of educational co-ordination than is at present found in the Union. Whether this will lead to a complete overthrow of the provincial system or merely to its modification will be for the country to decide.

V.

GEOLOGY.

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The African continent has a foundation of very ancient sediments and igneous rocks, which, towards the south, become more and more covered by Karroo beds (Carboniferous to Jurassic). In the country south of the equator, sediments which can be correlated with those of the Devonian and older Palaeozoic systems of other continents, have been recognized only south of 31½°, where they form part of a succession, which, still further south, is 10,000 feet thick, and passes up conformably into the Karroo system.

Since the oldest marine fauna yet found in South Africa (in the Bokkeveld series), is of Lower Devonian age approximately, there is doubt as to the correlation of much older sediments, and, although the terms Cambrian and Ordovician are sometimes met with in descriptions of South African geology, there is no other justification for their use than the fact that the beds are older than the Devonian. It is, therefore, advisable to use local names for stratigraphical units, more especially for those of the older systems.

The Cape system includes a succession of 5,000 feet of unfossiliferous, arenaceous rocks lying conformably below the Bokkeveld series; presumably these rocks represent part of the Silurian, but the evidence is incomplete. The unconformity at the base of the Cape system is very strongly marked, and what are here called the Pre-Cape formations may not include any Palaeozoic deposits.

There is a thick and widespread group of dolomitic limestones of Pre-Cape age in the interior of South Africa, and such rocks are generally thought to be of marine origin; if that view be correct, marine conditions prevailed over a very large part of the sub-continent long before the deposition of the Cape formation. With the exception of these dolomites, as well as of a thin group in the Dwyka series of South-West Africa, and narrow fringes of Cretaceous and later beds near the coast, there is no evidence of the sea having reached any part of South Africa north of latitude 31½°, while great thicknesses of continental deposits are characteristic of the whole region. The best known, and most important, of the several groups of continental deposits is the Karroo system, which is not only of extreme interest in providing evidence of Suess's Gondwanaland with its extensions or analogies in the Antarctic, South America, Australia and India, but also in containing large deposits of coal that are likely to be of even greater economic importance in the future than they are at present.

The oldest rocks are found in the north, in Rhodesia, the Northern and Eastern Transvaal and Swaziland, Natal, Bechuanaland, South-West Africa and the districts about the middle course of the Orange River. They are of sedimentary and volcanic origin, but are in general greatly altered by intrusions of granitic gneiss and by pressure. The name Swaziland system has long been used to include the stratified rocks older than the Witwatersrand beds, for the relation of the several isolated groups is not known. In all the great areas of granitic gneiss there lie rocks whose mineral constitution and structure show them to have been sediments or volcanic beds. In several such areas the origin of the smaller fragments is found in great bodies of stratified rocks, from which the fragments have become separated by the intrusive rock and earth-movements.

In the Transvaal and Swaziland, one of these great formations is divided into three series, Moodies, Onverwacht and Jamestown; the first, which builds up the rugged Barberton Mountain Land, consists chiefly of quartzites, slates and banded ironstones; the second is mainly volcanic, and the third consists of basic schists and sedimentary rocks. Moodies series appears again in Mount Mare and in the Murchison range, where there is much basic schist associated with it. The Pongola series in the S. E. Transvaal is divided into a Lower group, with great thicknesses of andesitic lavas, probably to be correlated with the Onverwacht series, and an Upper group of quartzites, conglomerates, shales and banded ironstones, which is probably an extension of Moodies series. In Natal the Nondweni and M'fongosi schists, and the Insuzi beds are perhaps parts of the same formation. All these beds are invaded by the "old" granitic gneiss supposed to be of the same age as that on the eroded surface of which the Witwatersrand

TABLE OF FORMATIONS.

				Maximum thickness in feet.
Pleistocene.			Sand, high level gravels, tufa, ironstones, surface quartzites, raised beaches.	
Cainozoic.			Marine inshore deposits; lignites of Knysna; Kalahari beds.	400
	Cretaceous system.		Needs Camp series (Danian).	
			Umzamba series (Senonian).	50
			Manuan Creek beds (Cenomanian).	50
		Uitenhage series (Neocomian)	Sundays River beds.	
			Wood beds.	4,000
			Enon conglomerates.	
Jurassic.	Karroo system.		Drakensberg volcanic beds.	4,000
Triassic.		Stormberg series.	Cave sandstone.	800
			Red beds.	1,600
			Molteno beds.	2,000
Permian.		Beaufort series.	Upper or Burghersdorp beds	3,000
			Middle Beaufort beds.	1,000
			Lower Beaufort beds.	7,000
		Ecca series.		6,200
Carboniferous.		Dwyka series.	Upper shales.	800
			Tillite.	1,400
			Lower shales.	1,000
Devonian.	Cape system.		Witteberg series.	2,500
Silurian?			Bokkeveld series.	2,500
			Table Mountain series.	5,000

Pre-Cape systems.	Waterberg system.	Sandstones, shales, conglomerates, lavas. (Matsap series of Griqualand West).	5,000 to 7,000
	Transvaal (Nama) system.	Rooiberg series, quartzites, shales, felsitic and andesitic lavas.	
		Pretoria series (Griquatown series, Ibiquas beds, Fish River beds), shales, banded ironstones, quartzites, lavas and tillite.	10,000
		Dolomite (Campbell Rand series, Malmesbury beds, Otavi Dolomite, Schwarzkalk, Sinoia Dolomite) and chert, lavas near base in Vryburg.	3,500
		Black Reef series (Kuibis beds, Nieuwerust beds). Quartzites, shales, conglomerates.	2,550
	Ventersdorp system.	Pniel series, mainly lavas, tuffs, etc., but also shales, quartzites, limestones. Kuip series; lavas, limestones, cherts, arkose, etc. Zoetlief series; acid lavas, shales, quartzites, conglomerates.	10,000
		(Possibly the Koras series (lavas and sediments) of the Orange River Valley, and the Konkip of South West Africa belong here).	
	Witwatersrand system.	Kimberley-Elsburg series; quartzites, conglomerates and shales.	6,000
		Main-Bird series; quartzites, conglomerates, lava flows.	3,000
		Jeppestown series; mainly argillaceous, some quartzites, lava flows.	4,000
		Government Reef series; quartzites, banded ironstones, thin shales, conglomerates, tillite.	6,000
		Hospital Hill Series; quartzites, shales, banded ironstones.	5,000
		Pongola series. — Upper Pongola; shales, quartzites, banded ironstones, conglomerates.	9,000
		Pongola series. — Lower Pongola; quartzites, phyllites, lavas.	11,000
		Kraaipan series. — Abels Kop beds; schists, quartzites, banded ironstones, limestones, cherts, lavas.	
		Kheis series. — Wilgenhout Drift beds, sedimentary and volcanic.	
		Kheis series. — Kaaien beds, chiefly arenaceous.	
		Kheis series. — Marydale beds, volcanic and sedimentary.	
	Swaziland system. (Intercorrelation unknown).	Moodies series; quartzites, shales, conglomerates.	30,000
		Onverwacht series; chiefly volcanic.	
		Jamestown series; schists.	
		Basement schists of Rhodesia.	
		Khomas Highland schists of South-West Africa.	

beds in the southern Transvaal were deposited. This distinction is the chief ground for not accepting the correlation of the Witwatersrand system with any part of the Swaziland, and it is supported by the presence of quartz-schists and basic schists in the granite north of Johannesburg, and banded ironstones in the granite below the Orange Grove quartzites in Heidelberg.

This difficulty with correlation in the southern and eastern Transvaal becomes greater in the west, where two large bodies of comparable strata are found. For 150 miles north-westwards along the Prieska-Kenhardt border, and extending past Upington, there is the Kheis series, divided into the Marydale beds (which are largely volcanic) below, the Kaaien series of quartzites and quartz-schists in the middle, and the Wilgenhout Drift sedimentary and volcanic series above. Many bodies of similar rocks, but generally more highly metamorphosed, lie in the gneiss on either flank of the main area. The Kraaipan series occupies a wide area in Bechuanaland (Mafeking and Vryburg), but it is much hidden under sand. It resembles the Kheis series in many ways, though it is without such a thick arenaceous group as the Kaaien beds, and, in spite of the conversion of the volcanic rocks of the southern outcrops into hornblende schists and the presence of other highly metamorphosed rocks, the series is not known to be invaded by granite. The Abels Kop beds of the western Transvaal are probably an extension of the Kraaipan series, and granite is intrusive in them.

In South-West Africa there are great thicknesses of schists, quartzites and limestones much older than the Nama system, and also older than the Konkip. The most extensive area of these ancient rocks is the Khomas Highland on which Windhoek is situated. The similar rocks in the Great Kharas Mountains are not far from the Kheis beds of Gordonia. In Rhodesia, what are called the Basement Schists include more than one formation, for the Eldorado conglomerate group contains boulders of older schists and of granite like that intrusive in them ; while in another part of the country the Ndutjana series has a similar relation to the older rocks.

Volcanic rocks form an important part in almost all the ancient series, and when estimates have been made of the thicknesses of whole series, they reach

figures like 20,000 or 30,000 feet. Interesting work has been done in Rhodesia upon the evidence afforded by some of these very old rocks as to the contemporary climate and conditions of sedimentation, pointing to less oxidation of detritus and greater effect of erosion before the appearance of green plants.

The " old " granites and gneiss, which are in great part younger than the rocks collected in the Swaziland system, occupy a large area stretching with minor interruptions through eleven degrees of latitude south from the lower course of the Zambesi, on the eastern side of the continent; small inliers are met with further south in Natal. Important inliers are found near Shoshong, at Gaberones, between Pretoria and Johannesburg, at Parys, and at Mafeking; on the west the old granites are less continuously exposed from the Cunene southwards to Nieuwerust, fourteen degrees of latitude.

Though there are many rocks grouped under the Swaziland system which are clearly ordinary sediments or limestones, the Witwatersrand system is the earliest group of sediments of which the lateral variation has been studied in considerable detail, and which allow conclusions to be drawn about the geographical conditions during their formation.

Extensive mining on a narrow horizon has afforded opportunity for the study of some conglomerates which is unequalled in any other region of pre-Cambrian rocks. The system has been definitely recognized only in the Witwatersrand, Heidelberg, Klerksdorp, Vredefort and a few smaller inliers in the southern Transvaal and the northern Orange Free State. Though the maximum thickness of the sedimentary rocks in it exceeds 20,000 feet, they do not include limestones; other notable features are the great areas through which some thin conglomerates, the Main Reef Leader with its persistent gold values, and the Government Reef, extend, the even

greater persistence of some banded ironstones, and the presence of a tillite or boulder-mudstone of glacial origin.

The basal beds of the Hospital Hill series are generally white quartzites (Orange Grove quartzites) with a few pebbles at places; these quartzites are separated into three groups by two bands of shales, and they make prominent escarpments north of Johannesburg and east of Heidelberg. In Vredefort some 600 feet of metamorphosed amygdaloidal lavas lie below the Orange Grove quartzites. A great thickness of shales, including two bands of very ferruginous and siliceous rocks, often thinly laminated (Water Tower slates and Contorted beds), lies above the basal quartzites; some thin but persistent quartzites are also interbedded with these shales, the upper one, just below the contorted beds, having much felspar in it, which weathers white and gives the rock its name, Speckled bed. The upper part of the series is made of thick bands of quartzites with intervening shales, and the dip-slopes of the lowest of these quartzites are very conspicuous in Johannesburg. The two upper bands of quartzites are not seen in Johannesburg, on account of strike faults; they are remarkable elsewhere for the structure called "sago," seen in many lenticular layers in which a very fine-grained matrix encloses almost spherical grains of larger size. Though the succession in the Hospital Hill and higher series of the Lower Witwatersrand beds has been completely worked out on the Rand, in Heidelberg and in Vredefort, it is nowhere seen in its entirety along one line of section, and this fact was the cause of great confusion until Dr. Mellor (1911) had pieced the disrupted fragments together and traced the faults which cause the gaps and repetitions on the Witwatersrand.

The Government Reef series is a more regular alternation of shales and quartzites. At the base of three of the quartzite groups there are thin conglomerates, the one known as the Government Reef being

very persistent. A band of laminated ferruginous shales, the West Rand or Coronation shales, is conspicuous below the Coronation Reef, and is separated from it by a boulder-mudstone or tillite with striated stones at places so far apart as Heidelberg and Klerksdorp, though the tillite has not been proved on the Rand or in Vredefort.

The Jeppestown series is chiefly argillaceous, but it has quartzites in it, and, in certain areas, volcanic rocks. It is the weakest member of the system, and its outcrop varies greatly in width owing to strike faults.

The series so far described are as a whole weaker or less " competent " than the remaining series which constitute the Upper Witwatersrand beds, and in each region hitherto mapped in detail the three Lower series have been affected by faults to a much greater extent than the mainly arenaceous upper beds.

The lower limit of the Upper Witwatersrand beds is drawn at the base of quartzites containing, in the Witwatersrand and Heidelberg, one or more beds of conglomerate. It is known that the change from the slates of the Jeppestown beds to the quartzites does not take place on one and the same horizon even throughout the Rand, but the conventional limit is necessary for mapping these unfossiliferous beds. In many sections no discordance has been detected at the limit, but in the Far East Rand and Heidelberg slight unconformity is often seen. The Main-Bird series is the lowest sub-division of the Upper Witwatersrand beds ; it includes three conglomerates, known collectively as the Main Reef group of conglomerates, which are distributed in the Central Rand through some 180 feet of strata about 600 feet from the bottom of the series.

The lowest is the Main Reef, which may be 12 feet thick, and is made of rather small pebbles unsorted ; it has no sharply defined footwall, and it is often split up by layers of quartzite. It thins out towards the east and

the quartzites below and above it become more and more argillaceous, passing laterally into slates. The Main Reef Leader lies directly on the Main Reef in the west, but becomes separated from it by as much as 60 feet of quartzite, and a dark, chloritoid-rich, argillaceous quartzite or grit towards the east, while in the Far East Rand, where it usually lies on slates, it is the only reef mined, with the exception of some upper "leaders," which, so far as is known, are limited to a few mines. It is the chief producing reef in the field. It has a sharply defined footwall and the pebbles are graded. The third bed, the South Reef, lies on the leader in the East Rand, and becomes separated from it by about 110 feet of quartzite towards the west; it resembles the Leader in having a defined footwall. The quartzites above the Main Reef group are as much as 3,000 feet thick in the Central Rand and contain several conglomerates of small pebbles, the best known of which is the Bird Reef group; they also contain, above the Bird Reefs, on the Central Rand, a detrital rock made of chlorite, sericite, chloritoid and quartz grit, called the Bird Reef Marker, and amygdaloidal lava, the Bird Amygdaloid, on the same horizon further east, in Heidelberg and in Vredefort. Above this horizon the quartzites of the Main-Bird series pass upwards into slate by increase of the amount of argillaceous minerals. This slate, the Kimberley slate or shales, is reckoned as the base of the Kimberley-Elsburg series, and is as much as 600 feet thick. It is the only thick slate in the Upper beds. Above these slates are at most some 5,500 feet of quartzitic beds, which include two groups of lenticular conglomerates, the Kimberley below and the Elsburg above. The Elsburg beds south of Johannesburg and in Heidelberg, pass upwards into the green volcanic beds of the Ventersdorp system through a band of rock in which green detrital or pyroclastic material of volcanic origin gradually preponderates over the siliceous detritus.

The whole Witwatersrand system appears to have been formed in a non-marine area, for there are no calcareous beds in it. The Main-Bird series in particular has the characters of a deltaic deposit, and the Leader and South Reefs probably represent sheets of gravel distributed over flood-plains by means of water concentrated in anastomosing channels, in which the layers of pebbles were thicker than in the areas between them. The source of sediments was, in the Johannesburg area, to the north, but the parentage of the pebbles has not been traced; quartz and quartzite preponderate, cherty rocks are less abundant, while quartz-porphyry and slaty rocks are rare. The original constituents of the matrix, especially the aluminous and ferrous minerals, have been much altered, the most marked result being the presence of secondary quartz, pyrites, chlorite, sericite and chloritoid. Mellor's conclusion that the gold is detrital in origin, but has been recrystallized, has been strongly supported by subsequent work.

Reference has been made to the strike-faults on the Rand; evidence indicates that what are now the northern outcrops of the lower half of the formation were given their steep dips, were faulted, and were undergoing erosion while the upper beds were still being deposited a few miles to the south, for coarse conglomerates, like those of the Elsburg group, eventually spread over part of the eroded lower beds, an instance of unconformable overlap that is still more clearly exhibited by the Ventersdorp lavas. The great syncline south of the Rand became fully developed at a later date, for the whole Transvaal system is involved in it. Faulting extended over a very long period; the reversed faults (*e.g.*, the Rietfontein and Witpoortje faults) were, in some cases, completed before the Black Reef series was laid down, while the great Sugarbush normal fault was later than at least part of the Dolomite.

The Witwatersrand beds are known to exist over a comparatively small area, but the Ventersdorp beds have been recognised from the Dwarsberg in the north to Prieska, a distance of 800 miles, and over a width of 300 miles, without counting their doubtful correlatives near Upington (Koras series) and in South-West Africa (Konkip system). The greater part of the Ventersdorp formation is of volcanic origin, lavas of intermediate and acid composition, but thick sediments ranging from coarse conglomerates to limestones are found in several areas. The volcanic sequence is 11,000 feet thick near Ventersdorp, where quartz-porphyries are not seen. The period was one of considerable earth movements, as witnessed by the two marked unconformities in Bechuanaland and Prieska. The lavas, though much altered, resemble those in the Witwatersrand beds and also those of later date near the bottom of the Dolomite in Bechuanaland and on the Transvaal border.

From the facts at present known it appears that the volcanic activity during the Ventersdorp period was perhaps the most intense and long lived that South Africa has yet experienced, although the much later (Jurassic) basalts of the Stormberg group are preserved, or are recognizable, over a much greater area.

The Konkip system of South-West Africa may be represented by the four series, Stinkfontein, Kaigas, Numees and Groot Derm south of the Orange River. The highly-folded quartzites of the Stinkfontein series include a volcanic group, and are overlain by the limestones and shales of the Kaigas ; the next series, Numees, contains a thick tillite, and the Groot Derm series is made of volcanic and sedimentary beds. The tectonic structure of the areas occupied by these beds is complicated, and much more work remains to be done on them before their correlation can be satisfactorily discussed. The presence of abundant boulders of granites and gneiss indicates that

the formation is younger than some of the old granites, but the beds were invaded by gneissose granite and also by the younger-looking Kuboos granodiorite.

The rocks of the Transvaal (Nama, Lomagundi) system are more widely spread than those of any other pre-Karroo formation. The Lomagundi beds appear near the Zambesi, and the Nama on the Cunene. The structure of the Transvaal system is well known in the Transvaal, and as far south as Prieska, and the Nama formation, which is probably a correlative of the Transvaal system, has been followed, with comparatively short gaps caused by denudation or concealment, down the western side of the continent to Cape Town. The unconformity at the base of the three correlated formations is the most extensive stratigraphical break in the sub-continent, though in the middle region about Mafeking and Vryburg, identity of character of the Ventersdorp lavas below it and those a few hundred feet above indicates that the time represented by the unconformity there and in the southern Transvaal may not have been great.

The basal beds of the system are quartzitic, often also conglomeratic, and in the Transvaal (Black Reef series) they vary in thickness from a few feet to 2,000 feet. The Black Reef series forms the Drakensberg escarpment of the eastern Transvaal, part of the great escarpment of hard beds which limits the Orange-Limpopo catchment from those of the streams running directly to the coast. The succeeding beds are the Dolomites (Campbell Rand series, Schwarzkalk, Malmesbury beds, Sinoia limestones), with a maximum thickness of 3,500 feet in the Transvaal, accompanied by shales or slates ; towards the south-west non-calcareous sediments replace much of the limestone, or all of it in certain areas, but the structure of the large areas of Malmesbury beds in the Western Province still awaits elucidation. In all the areas where the limestones are well exposed there are caves, under-

ground water-channels and the rough outcrops usually met with in such rocks.

The Pretoria series follows the Dolomites conformably or with slight unconformity; complete overlap has not been recorded. In the Transvaal there is a regular succession of shales, Timeball Hill quartzites (with magnetite quartzites), shales and andesitic lavas and tuffs, Daspoort quartzites, shales and Magaliesberg quartzites with some shales and thin limestones above them; the three groups of quartzites usually make prominent ridges, such as those near Pretoria. The whole succession is over 12,000 feet thick in the east and south of the central Transvaal Bushveld. Towards the west, the lower beds become more ferruginous, approaching in character the conditions found in Griqualand West and Prieska, where banded ironstones form the long range of hills stretching from the Doornberg near Prieska for 300 miles to the north as the Asbestos and Kuruman and Heuning Vlei hills before turning north-east and becoming lost in the sand as they strike towards the Transvaal outcrops, 150 miles away. The volcanic or Ongeluk beds are well developed in that region, and are separated by thinly laminated beds from a tillite below, which is recognizable also in the Transvaal. The prominent quartzite groups of the Transvaal have not been found in Griqualand West, where it seems that the lower half only of the succession as developed in the Transvaal is represented.

In South-West Africa the Nama system covers a great part of the extensive plateau in the south; the Kuibis quartzite and the Schwarzkalk (with the Schwarzrand beds) correspond broadly with the two lower series of the Transvaal system and the Fish River beds with the Pretoria series. A very interesting feature in the south of that territory, and the adjoining district of Gordonia, is the reappearance of hills of pre-Nama granite and

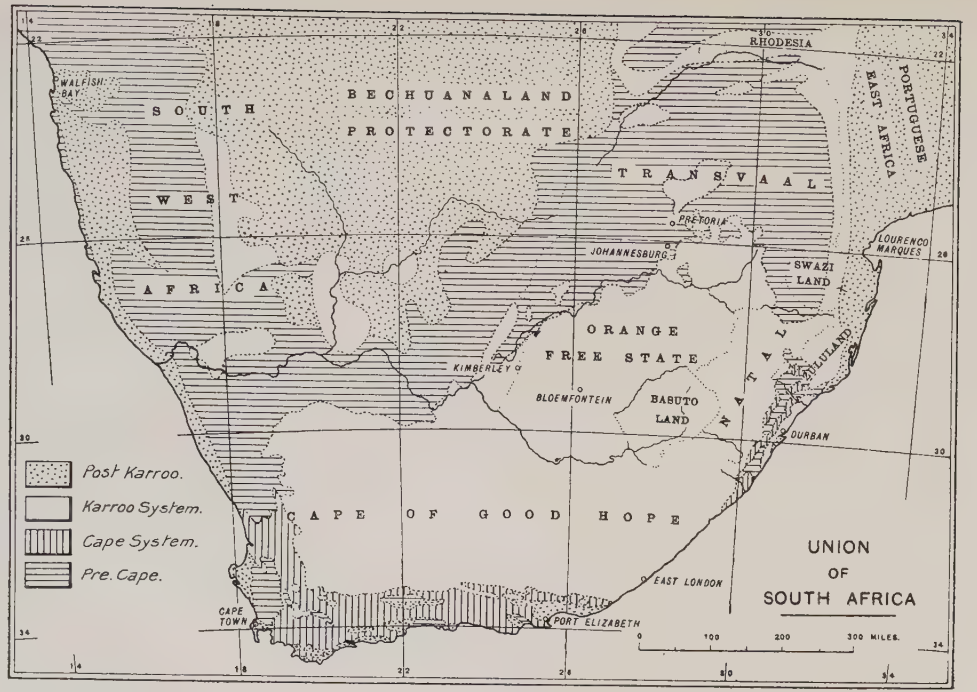

Plate 10.] GEOLOGICAL MAP.

schists from beneath the Kuibis quartzite, under which they were buried.

The Rooiberg series consists of felsitic and fragmental volcanic rocks accompanied in some areas by conglomerates, quartzites which generally contain much felspar, and shales. Its relation to the Pretoria beds is obscure, but there appears to be unconformity. The volcanic rocks are believed to be the earliest surface products of a period of igneous activity which eventually gave rise to the Bushveld Igneous Complex, a most important element in the structure of the Transvaal. The magma, which solidified as the Rooiberg felsite, appears to have broken through the floor made of the three lower members of the Transvaal system, the upper part solidifying as felsite and the lower as granophyre. At a later period came the intrusion of a more basic magma ; the sedimentary floor sank and the basic magma filled the basin and had the Rooiberg series for its roof. The sinking of the floor gave rise to the synclinal arrangement of the Transvaal system with a longer axis of 300 miles from Lydenburg westward to Ramutsa and a width of over 100 miles. The basic magma underwent differentiation in place through repeated gravitational separation of crystals, producing the remarkable stratification of the igneous rocks as we now see them. In places, such as the Lulu Mountains, the rocks look from a distance like bedded detrital rocks. Norite, anorthosite, gabbro, pyroxenites and rocks made chiefly of chromite and titaniferous magnetite are the chief kinds seen. Platinum is concentrated in certain of the norites and peridotites and is being extracted on a commercial scale. At a later date a more acid magma intruded in general between the already solidified basic rocks and the overlying Rooiberg series ; it formed the red or newer granite of the Transvaal, and is at different places to be seen in contact with most of the rock series from the Rooiberg downwards. Many intrusions of dolerite and other rather basic rocks in the pre-Waterberg

formations outside the Central Bushveld are believed to be off-shoots from the magma which gave rise to the Complex. The rest of the Union and South-West Africa have nothing analogous to the Complex, but in Rhodesia, the Great Dyke, a remarkable structure about five miles wide and extending 300 miles N.N.E. from near West Nicholson, has been shown to be closely related in the nature of its component rocks, while their arrangement in places suggests differentiation *in situ*, as in the Complex.

The metamorphic aureole about the Complex is well developed, reaching a width of 16 miles in Zeerust ; the affected rocks formed the floor rather than the sides of the Complex, and their great width as now seen has, no doubt, been caused by the removal of the edge of the mass of igneous rock. The norite, to which owing to its position the contact metamorphism is to be attributed, is at places contaminated by solution of sedimentary material.

The Rooiberg series and part of the plutonic rocks had been removed by denudation before the thick red conglomerates, quartzitic sandstones and shales of the Waterberg system were deposited. In the Zoutpansberg, this formation has a thick group of andesitic lavas at the base, but elsewhere in the Transvaal the reddish sandstones of continental origin, up to 5,000 feet thick, have no associated lavas. The Waterberg beds form the Zoutpansberg in the north, which is almost continuous with the north-eastern extension of the great Palala region west of Potgietersrust, and a smaller stretch of country between Pretoria and Middelburg. The latter tract has a synclinal structure roughly concentric with that of the eastern half of the syncline formed by the Transvaal formation, as though the sinking of the floor of the Complex had continued until after the Waterberg beds had been deposited. In the northern districts of

the Cape Province, the Waterberg system is probably represented by the Matsap beds, similar in lithological character, but having a volcanic group in the middle of the succession. The formation is probably over 10,000 feet thick. It rests on Griquatown and older rocks in the Langeberg and Korannaberg, which are parallel ranges extending in all about 180 miles northwards from the Ezel Rand in Prieska, with inliers amongst the sand reaching 100 miles further north. A connection with the Waterberg beds of Kanya in the Protectorate may be concealed by the sand.

Both in the Transvaal and the Cape Province the very considerable disturbances to which the Waterberg-Matsap beds have been subjected, are older than the Karroo system, the lowest beds of which rest undisturbed on the older formation that had not only formed mountains of the folded type, but had been reduced to remnants by denudation before the beginning of the Karroo period. The Waterberg-Matsap beds have been regarded as the northern equivalents of the Cape system which is known only in the south, a suggestion which is not supported by a comparison of the structure of the two regions. The chief reasons for the correlation are similarity in type of deposit, the Table Mountain series becoming in general more red as it is followed northwards in Natal where it approaches the Waterberg beds, and the fact that each formation is intermediate in age between the Transvaal and Karroo systems. Were there proof of the suggested Waterberg age of the sandstones and conglomerates of Klipheuvel and other places not far from Cape Town, it would also prove the pre-Cape age of the Waterberg, but at present, unfortunately, there is none.

In Rhodesia, the Umkondo formation of the south-east (Melsetter, Spungabera) has thick limestones in it, but from the description of the bulk of the sediments, they are like those of Zoutpansberg, and andesitic lavas

are also associated with the Umkondo sediments, which reach a place only some 80 miles distant from Zoutpansberg.

No granite intrusions have been found in the Waterberg beds or their correlatives. In the Transvaal, there is a series of alkaline volcanic and intrusive rocks, of which the chief instance is in the remarkable circular island-mountain group eighteen miles wide, called Pilandsberg, in the eastern part of the central Bushveld. It is situated on the axis of the Complex where a belt of foyaite dykes crosses it ; phonolite lavas and tuffs were first ejected, according to Prof. Shand's conclusions ; then foyaite intruded between the floor of granite and norite and the volcanic roof, and a ring-shaped structure arose through the fracture and faulting of the roof and injection of foyaite amongst the blocks. The age of the group has not been determined, and it may be as late as post-Waterberg. Other alkaline groups extend interruptedly from near Premier Mine, 25 miles N.N.W. to beyond Haman's Kraal. Yet another group, small in size and number, is connected with the origin of one of the most fascinating structures in the Transvaal, the Vredefort Mountain Land, with its core of old granite and schists surrounded by a ring-shaped, faulted, and often inverted succession of metamorphosed strata from the base of the Witwatersrand system to the Dolomite.

The southern Cape granites are only known to be younger than the Malmesbury beds and older than the French Hoek-Ibiquas beds (possibly correlatives of the Pretoria series, or of the Waterberg as Dr. du Toit thinks) and much older than the Cape System. These granites form several large areas from the Peninsula northwards to Van Rhyns Dorp and westwards to George, but there is room for doubt as to the contemporaneity of the George granite and the western masses. There is a parallelism in the structure and lie of many of these masses, not only with the strike of the beds invaded but also with the trends of the much younger Cape folds.

The Cape system has a thick series of continental grits (Table Mountain series), including a glacial group, at the base, followed by about 1,500 feet of shales and sandstones with marine fossils of Lower Devonian affinities (lower half of Bokkeveld series) and then by some 3,500 feet of continental deposits (upper half of Bokkeveld and the Witteberg series). The Table Mountain series builds up the chief ranges in the Cape, not only because it was involved in the folds, but on account of its resistance to weathering, which has removed the softer overlying strata. Towards the east, where the amplitude of the folds decreases, it is replaced in this respect by the Witteberg beds. South of latitude 32½° the Witteberg is followed conformably by the Lower Dwyka Shales (base of the Karroo system), which pass up into the tillite, usually without a sharp limit. The maximum thickness of the tillite in the south is 1,400 feet ; it contains many boulders and pebbles derived from pre-Cape formations north of the Karroo region. The unconformable overlap of the basal Karroo beds over the Cape formation is completed within 120 miles on the west, and in that distance the tillite becomes very much thinner, its thickness at any point depending chiefly on the shape of the floor. North of latitude 28° it is often absent, and it has not been recognized in Rhodesia ; in the Transvaal its erosion in early Karroo times gave rise to much conglomerate of the usual type in the Ecca beds, the lower part of which, as seen in the Cape, is missing. The glacial phenomena associated with the tillite are finely exhibited in the Kaap valley, a pre-Karroo valley in Griqualand West, which is now being cleared of its burden of Karroo beds. Several centres of ice-distribution, from South-West Africa across to the Indian Ocean, have been recognized. The shales above the tillite (Upper Dwyka shales) are sharply separated from it ; they include dark, carbonaceous shales, and have a small fauna of fresh-water type, but in the south of

South-West Africa marine forms occur in them, the only marine fossils known from the Karroo beds. These shales and the lower part of the Ecca are not developed in the Transvaal or Rhodesia, where the Middle Ecca is coal-bearing, as it also is in Natal and the northern Orange Free State, though not in the Cape. The succession of 15,000 feet of sediments above the Dwyka in the Karroo region is divided up into the Ecca, Beaufort and Stormberg series. The Ecca and Beaufort there present many instances of contemporary erosion, but no pebble beds; the long succession of amphibian and reptilian fossils for which the Beaufort beds are famous begins in the Ecca, and the clay-pellet conglomerates seen lining the contemporaneously eroded hollows often contain pieces of bone.

The region south of latitude $31\frac{1}{2}^{\circ}$ was subjected to great lateral pressures before the deposition of the Beaufort beds was completed. The movements started in the west at a much earlier date, probably in Carboniferous times, and continued until Beaufort times, resulting in the production of the Cederberg folds with N.N.W. trend; in the south, the beginning was delayed, possibly until the Beaufort beds were being deposited, and a result was the series of east-west arc-shaped ranges, concave to the south and overfolded towards the north, marking what are called the Zwartberg folds. The two sets met in the region between Tulbagh and Caledon, where diagonal folds arose, and the whole group is called the Cape folds; the mountains made of the resistant folded rocks are the Cape Ranges. It had been suspected that the Cape Ranges were in existence during early Stormberg times before the discovery that the Zuurberg volcanic rocks and the underlying, ossiferous, white sandstones were almost certainly of Stormberg age, and had been laid down after the rocks involved in the Zwartberg folds had been subjected to denudation.

The Stormberg series has for its base the Molteno beds, the coarse grits and conglomerates of which indicate deposition at a less distance from sources than the Beaufort beds of the same region ; the fossil flora points to their Triassic age, but no animal remains have been found in them. The overlying Red beds and Cave sandstones overlap the Molteno and much of the lower series of the Karroo formation northwards from Basutoland and also to the south, where they reached the Zuurberg behind Algoa Bay after the Cape folds had been completed there. The Red beds have yielded a considerable fauna, chiefly dinosaurs, but fewer are known from the Cave sandstone, that rock probably having been laid down on land under arid conditions, a conclusion supported by the enclosed pan deposits with crustacean and insect remains. The Cave sandstone is extensively developed in the northern Transvaal (Bushveld sandstone) and Rhodesia (Forest sandstone), while in South-West Africa it is represented by sandstones below the Kaokoveld basalts and by the Waterberg sandstone of the north-east. There is a great overlap in this region also.

During the deposition of the Cave sandstone, volcanic activity began in the Stormberg region by the opening of vents and the ejection of tuffs and lavas. These volcanoes were buried under lava from fissures ; the plateau basalts reached a thickness of about 4,000 feet on the Natal border and covered a great area about Basutoland, the Central Transvaal Bushveld, the Waterberg flats, the Lebombo, Limpopo and Tuli regions, the Middle Zambesi, and the Mariental and Kaoko regions in South-West Africa. In the Lebombo, they are succeeded by great thicknesses of more acid lavas, and in the Limpopo valley they are apparently accompanied or partly replaced by limburgites, augitites and nepheline basalts. In the Zuurberg region they are represented by analcite basalts. These isolated areas embrace a very large region, and it is not known how far they were connected by lava-fields

since destroyed ; large boulders of similar basalts in the younger volcanic pipes of Griqualand West, Carnarvon and other districts, give evidence of some former extensions. The whole great region is, however, penetrated by dykes and sheets of dolerite belonging to the same magmatic source as the lavas and partly of slightly later date. The Folded Belt is the only large part of South Africa which is free from these intrusions ; the magma which solidified as dolerite would seem to have been unable to make its way amongst the strata which had then but lately yielded to tangential pressures and had formed the Folded Belt.

During Stormberg times the Folded Belt was exposed to denudation, and the earliest deposits of later date than the folding, laid down on or near the folded rocks, belong to the upper groups of that series. By Neocomian times thick conglomerates and other continental deposits were filling in the great longitudinal valleys in the Folded Belt, which, towards the east, opened into the sea. These beds are the Uitenhage series, the original landward limits of which are not known, but it seems probable that they covered part of the ranges between the infilled valleys and were continuous with the surface on which the river system was established on the land to the north made of the Karroo formation. At a later date in the Cretaceous period the infilled valleys were let down along important east and west faults close under the Langeberg, Zwartberg and Zuurberg ranges. The main rivers probably cut down on to these ranges ; they were superimposed on them, having started their careers on Karroo beds in the north and the Uitenhage beds covering the Folded Belt. Cainozoic beds lie undisturbed across one of these faults in the east.

At some date later than Neocomian, there took place the volcanic activity responsible for the production of vents traversing the whole of the sedimentary cover of

GLACIATED ROCKS AT NOOITGEDACHT, KIMBERLEY DIVISION, SHOWING DWYKA TILLITE RESTING ON STRIATED FLOOR OF PNIEL DIABASE.

Plate 11.] [*Photo by A. M. Duggan-Cronin.*

the earth's crust in South Africa. In the south some of these vents are filled with melilite-basalt, others with breccias with pieces of granulite of deep-seated origin; in the north the usual contents are the peridotites and breccias called kimberlite, and diamond occurs in some of these.

Since Neocomian times the sub-continent has been rising in level. Though there were periods of little or no movement during which were formed the great peneplains whose remains are found in the interior as well as on the flanks of the Cape Ranges, there has been no reversal of movement sufficient to bring about marine transgression inland of the ranges. The upper Cretaceous beds of the the east coast may be contemporary with the quiescence, when also the Bushmanland valleys may have been filled with the local detritus from which dinosaur bones have been obtained, and perhaps the beginning of the thick deposits in the Kalahari dates back as far. The marine Cainozoic beds of the coast belt are a fringe, and they have as yet been insufficiently studied, but important evidence is likely to be obtained from them and from the still later raised beaches. The deep erosion of the valleys near the coast, proved by the over-deepened lagoons, may have happened in the Pleistocene, and part of the Agulhas bank was then almost certainly dry land; since that time the sea has reached a level of about 20 feet above that at which it now stands.

VI.

A BRIEF SURVEY OF THE WITWATERSRAND GOLD FIELD.

By The Gold Producers' Committee,
Transvaal Chamber of Mines.

Introduction.—In the following brief account and general description of the Witwatersrand Gold Field will be found a short statement of the Rand's history, an outline of the methods of working and a summary of essential statistics. The main geographical and geological features of the Field are also touched upon, but it is not intended to convey more than a general impression of the Witwatersrand Gold Field.

Where reference to geological features is made, the works and publications of the Geological Survey of the Union of South Africa, of Professor R. B. Young, Dr. E. T. Mellor, Dr. F. H. Hatch, the late Dr. G. S. Corstorphine and other geologists have been drawn on.

A few photographs are reproduced, illustrating mining operations and the character of the gold-bearing formation in the mines.

Discovery of the Rand.—The gold-bearing conglomerates of the Witwatersrand Main Reef Series, which have up to date produced gold to the value of about nine hundred and seventy million pounds sterling, and have for some years past been producing more than one-half of the gold output of the entire world, were discovered in 1886 by the late George Walker on the farm Langlaagte, three or four miles to the west of the centre of the City of Johannesburg.

Prior to this, gold had been recovered from reefs underlying the Main Reef Series on the West Rand, notably from the Confidence Reef, by the brothers F. T. P. and H. W. Struben.

Walker's discovery was quite accidental. It is related that one Sunday morning, whilst strolling over the farm Langlaagte (where he was erecting a homestead for the owner), Walker tripped over an outcrop of conglomerate hidden in the grass of the veld. Subsequent investigation proved this to be gold-bearing, and in this manner was unearthed a mineral deposit, the development of which has been the outstanding feature of the history of South Africa during the past half-century.

Geographical Features.—The Witwatersrand Gold Field is situated on an elevated plateau, nearly 6,000 feet above the sea. The Witwatersrand projects somewhat above the plateau, and the outcrop of the conglomerate reefs can thus in a measure be said to be the dividing watershed between the Atlantic and Indian Oceans ; rain falling south of the escarpment forms tributaries of the Vaal River, which drains into the Atlantic, and rain falling north of the escarpment finds its way to the Limpopo and Crocodile Rivers, which flow into the Indian Ocean.

Chief Productive Areas of the Field.—Geographically speaking, and to some extent in a geological sense as well, the Witwatersrand Gold Field may be divided into four sections, viz. :

1. The Central Rand, extending from Boksburg on the east to Roodepoort on the west, with the City of Johannesburg (the administrative headquarters of the Industry) situated approximately in the centre of the whole Field.
2. The West Rand, situated to the west of the Witpoortje "break" or "fault," beyond Roodepoort. The gold-bearing beds continue with a

roughly east and west strike through Krugersdorp, and then swing round until they attain a north and south line of strike, with a dip to the east at a high angle of inclination in the Randfontein mines.

3. The Far East Rand, extending from the New Kleinfontein Mine, immediately to the east of what is known as the "Boksburg Gap," or "break," to Springs and Daggafontein Mines. In the Far East Rand Section the reefs lie at a flat angle of dip (average about 10 degrees), and in this area are situated some of the most profitable gold mines of the world.

4. The Nigel District, lying to the south-east of the Springs-Daggafontein workings. In this area, the Sub-Nigel is at present the only working mine, but in view of the excellent returns recently secured by that Company, it is possible that other concerns will become active.

Identity and Nomenclature of the Reefs.—Questions relating to the identity of the reefs throughout these areas have been debated in geological circles for many years.

The arguments adduced in these controversies are of too technical and lengthy a nature to be dealt with here, and it will merely be noted that some have denied that the most profitable conglomerates on either side of an area near Boksburg, in which there are no working mines, belong to the same group. The weight of authority, however, inclines very definitely to the view that these conglomerates do belong to the same group, *i.e.*, the Main Reef Group, which furnishes most of the ore mined throughout the field, though other beds of conglomerates, which have received various names in different areas, are being mined to a limited extent.

Plate 12.] PNEUMATIC PICK IN OPERATION. NOURSE MINES.

Limits of Profitable Sections.—To the south-west of Randfontein, the Witwatersrand formation is covered by the dolomites, and to the south-east of the Nigel, the gold-bearing formation continues past Heidelberg and Balfour.

At different times considerable work has been carried out on these outlying sections of the Witwatersrand proper, and in some areas mines have been brought to the productive stage, but up to the present no profitable mines have been developed in these areas. It is, however, quite possible that in the course of time, provided that economic conditions are satisfactory, profitable mines may be established to the south-west of Randfontein and to the south-east of the Nigel-Heidelberg area, but insufficient data are at present available to justify any safe predictions as to the expansion of the Industry much beyond its existing geographical limits.

Main Geological Features.—The conglomerate beds of the Witwatersrand are composed mainly of quartz pebbles bound together by a siliceous cement containing iron pyrites. The name "banket" is a Dutch word which has been given to the conglomerate, from its general resemblance to an almond sweetmeat, and refers specially to the ore taken from the oxidised zone, which, in the early history of the Field, was called "free milling," and was found to extend only to a limited depth. The banket occurs in a series of quartzites and shales, known as the Witwatersrand System, which constitutes a formation succeeding in age the archaean schists of Barberton.

The Witwatersrand System.—The Witwatersrand System has been divided into a Lower and an Upper Division. The Lower Division is characterized by many slates and few conglomerates, while the Upper embraces quartzites, grits and numerous conglomerates, with little slate. The Division is conveniently made at the floor of the large series of quartzites, in which the Main Reef

series of conglomerate beds occurs. Since, however, the whole series is quite conformable, the separation is arbitrary, and is not intended to convey the idea of any want of geological continuity.

Lower Witwatersrand Beds.—The Lower Witwatersrand beds are well exposed in the range of low hills that form the northern boundary of the fields from Boksburg to Krugersdorp. These hills are the highest portion of the elevated tract of country known as the Witwatersrand, or, briefly, the "Rand." The range has an abrupt escarpment on the north, but southward it slopes gradually to the outcrop mines. Johannesburg and the numerous outlying townships which extend east and west along "the Reef" have been built on this slope. A section taken across the beds immediately to the north of Johannesburg shows four or five ridges of quartzite, alternating with broader belts of slate which, on account of their inferior resistance to agencies of denudation, generally form shallow depressions or valleys. The beds dip southward at angles varying from 45° to 85°, the total width of the outcrop from the granite to the Main Reef conglomerate being a little over two and a half miles.

The Upper Beds.—The Upper Division of the Witwatersrand System consists of conglomerates, grits and quartzites, with a few slate beds. The rocks are characterized (1) by being made up almost exclusively of quartz, orginally deposited as pebbles, sand and fine slime or mud; (2) by the presence of a large amount of secondary silica (in great part quartz), which has cemented the loose beds of sand, pebbles and fine silt into hard compact beds of quartzite, conglomerate and slate; (3) by the presence of iron pyrites and gold in certain of the conglomerates; and (4) by the presence of sericite in lustrous, silvery scales and films, especially in those

portions of the beds which have been faulted, squeezed and subjected to shearing.

Among the above-mentioned beds, quartzites largely predominate, forming the bulk of the whole series. The slate beds are, with one exception (that underlying the Kimberley Reefs), quite insignificant; and the conglomerates are plentiful only in certain well-defined belts, which are conveniently grouped under the following names originally given them by the gold prospectors:

5. Elsburg Series.
4. Kimberley Series.
3. Bird Reef Series.
2. Livingstone Reef Series.
1. Main Reef Series.

These conglomerate beds are separated by quartzites, but between the Kimberley and the Bird Reef Series the band of slate already referred to, occurs. In a typical section of the Central Rand the outcrop of the beds from the Main Reef to the top of the Elsburg conglomerates occupies a space of about four miles. The latter beds lie immediately north of the prominent ridge known as Klipriversberg, where they are overlaid by a sheet of amygdaloidal diabase belonging to the Ventersdorp System.

The Main Reef Series.—On account of its valuable gold contents, the Main Reef Series has been followed over a distance of nearly 100 miles, where it has been worked in almost continuous succession by the mining companies of the Witwatersrand.

The pebbles of the conglomerates consist mainly of white or smoky quartz embedded in a quartzitic matrix. In size they vary from that of a pea to that of a hen's egg, and there is a marked uniformity in this respect throughout extended portions of any particular bed, but some, on the property of the Luipaards Vlei Estate and Gold Mining Co., are even as large as an ostrich's egg.

A comparison between sections of the Main Reef Series at points far apart shows variations both in the number of beds and in the amount of quartzite between them. This is due to the thinning out and thickening of the various beds, variations which are characteristic of conglomerate, and inherent in its mode of formation. Close examination of any mine on the Rand shows that the banket beds, instead of preserving a uniform thickness over large areas, are rather of lenticular character; a particular bed will, if followed, be found to tail off until it ceases altogether, its place being taken, perhaps on a slightly different horizon, by another bed which, beginning as a small seam, gradually increases to a maximum width, when it, in turn, will commence to thin out. Further, some of the beds will be found to split up into several seams, which may or may not reunite; in the former case, lenticular patches, or "horses", of quartzite are enclosed. It follows that a conglomerate bed may be said to maintain only approximately the same horizon over great distances. Of the Main Reef Leader, however, it is true that there is a remarkable persistence over an extensive area, and the same statement applies, although less rigorously, to the Main Reef group of conglomerates as a whole.

Mineralisation of the Conglomerate Beds.—Examination under the microscope of sections of conglomerate from various mines shows a practically constant type of rock; the main differences in individual sections are the proportion of matrix to pebbles and the occasional occurrence of some particular mineral in greater quantity than the normal. The quartz pebbles show numerous fluid inclusions arranged in irregular lines. The pyrites occurs in all shapes, the rounded prevailing; sections of cubes and pentagonal dodecahedra and octahedra are found grading into partially or wholly circular pieces. The matrix contains chlorite, talc, sericite and, occasionally, ordinary muscovite; in some sections rutile is

Plate 13.] MODDER DEEP LEVELS. TIPPING ROCK.

abundantly present and zircon and chromite occur as accessory constituents. Corundum in pink-coloured grains and tourmaline in needles are mentioned by Henderson. With the talc and chlorite, chloritoid is associated in colourless prismatic sections, which are occasionally bifurcated and often broken.

Gold Content in the Reefs.—The occurrence of gold in certain of the Witwatersrand conglomerates has given them world-wide fame. Although rarely visible in the hand specimen, the gold can be easily seen under the microscope if specimens known to be rich are examined. The precious metal occurs in irregular, angular particles, often lying on the periphery of individual pyrites grains or crystals, or in the interstices between aggregates of that mineral. In many cases perfectly round pieces of pyrites may be observed to be bounded by gold particles. Only in rare cases are the particles of sufficient size to be visible to the naked eye, unless the ore has been previously crushed and the bulk of the sand removed by careful washing or " panning". Another content of the banket beds of economic value (particularly on the Far East Rand) is osmiridium. Diamonds, generally of a greenish hue, are sometimes recovered during milling operations, more particularly from the mines of the Far East Rand.

Early Scepticism.—Prior to the discovery of the Main Reef Series, virtually the whole of the gold output of the world was derived from rich alluvial " leads," and from quartz veins. None of these possessed any great extent of ore or prospects of permanence. When the Rand was discovered and gold was found in a sedimentary deposit extending over a very large area, it was unique in the history of mining. So novel, indeed, was the finding of gold conglomerates of the Witwatersrand, that in the earliest days of the Field some of the most prominent mining experts of that time were sceptical as to the endurance of the formation; several of them, indeed, condemned the Field.

Constancy of Gold Content.—The Rand has proved itself to be the most permanent and enduring gold field in the world. It has also proved itself to be the most consistent gold field ever discovered. Marked fluctuations in value occur, however, in limited areas; there are poor mines as well as rich and medium-grade mines, and in all the higher grade mines a certain amount of low-grade ore is also found. Although the form of the gold suggests precipitation from solution, its occurrence in "shoots" separated by lean or barren ground, is generally interpreted as indicating a sedimentary, or placer, origin for the gold. Nevertheless, the Rand is fully entitled to the distinction of being the most consistent goldfield ever discovered, because the distribution of gold in the ore over large areas is more marked in the Witwatersrand conglomerate reefs than in any other auriferous deposit of large size that has so far been found.

Persistence of Reef and Values.—The phenomena presented by this remarkable gold field, led many years ago to arguments as to whether the reef would persist in depth, and whether it might become poorer in much the same way as most other gold fields in the world have become poorer. In regard to the persistence of the reef, there is now but little doubt on this score; we know that the Main Reef Series continues to great depth and, excepting perhaps in the Far East, beyond the probable limitations of mining.

The matter of values, however, is less certain, but it is gratifying to know that, although there may have been some falling off, good values are still being obtained at the bottom of even our deepest mines.

Limitations of Working in Depth.—Dealing with the question of the depth of workings, in a recent special report on the life of the Witwatersrand Gold Field, Dr. Hans Pirow, Government Mining Engineer, remarked

that, on account of the exhaustion of payable ore in the upper levels, the depth of the existing mines is continually increasing, and 7,500 feet is regarded as the economic limit of working. On the Far East Rand the reef occurs in a basin formation, and is shallower, the maximum depth being estimated at 6,500 feet.

The greatest depth reached on the Witwatersrand is in the Turf Incline of the Village Deep, Ltd., which by the end of 1928 had reached a vertical depth of 7,500 feet below the surface. The rock temperature at the bottom of this shaft is 98·2° Fahr., but by ventilation and other methods, the temperature in the workings at this point has been reduced to about 85° Fahr.

An accompanying photograph, taken a few months ago, illustrates the condition of the ground at the bottom of this shaft, which is the deepest point to which man has descended below the surface of the earth.

The General Working Policy.—In the early days of the Rand only the richer portions of the outcrop could be worked at a profit, because of the difficult transport conditions and high working costs prevailing at that time. If the Rand had continued to be worked on this basis, it would have been a gold field of limited extent and prosperity, like Barberton; the Reef would have been "worked out" long ago, Johannesburg would have become a derelict town, and the development of the whole Union of South Africa would have been impeded. The variations in the value of the ore on the Witwatersrand are much less than are usually found in gold-bearing quartz occurrences. The variations, however, are considerable, not only from mine to mine, but in the same mine. Taken over its whole area, however, and down to the present working depth, the Rand is, relatively speaking, a low-grade field; the average value of the ore crushed by the mines is only about 6½ dwts. per ton.

Influences of Pressure of Strata.—As the mines have become deeper and the workings more extensive, the weight or pressure of the overlying strata has increased. Earth tremors are frequently experienced by residents of the Witwatersrand, and what are known as " rockbursts " or " pressure bursts," are phases of subsidence to which the mines are constantly liable. As a result, more and more labour has to be devoted to securing the workings by means of timber, waste packs, concrete pillars, discs and sand filling.

The number of natives employed on support of workings on the Rand, has been doubled during the last twelve years. There is thus a natural tendency for working expenditure to increase, and it is one of the main functions of the managements to endeavour to counteract this tendency by the employment of the most up-to-date mining methods, by the greater use of machinery and labour-saving appliances, and by general improvements in working efficiency.

Methods of Mining.—When the gold-bearing reefs are located and the necessary shafts sunk—at a cost (including shaft-sinking and equipment, initial development, plant, etc.) of anything from £1,000,000 to £2,000,000—the ground is first opened up by drives, raises and winzes. These divide the ground into blocks, which, if payable, are afterwards stoped, the average stoping width on the Rand being now about 50 inches. To-day practically the whole of the development and stoping is done by rock-drills operated by compressed air. As stoping proceeds, it is necessary in some cases to support both the sides and roof or " hanging " of the drives.

The drill now most commonly used in stopes is known as the jackhammer, and weighs only 50 lb. complete. It can be operated by one person, and is capable of drilling on an average 70 to 80 feet per shift, but under

favourable conditions can perform a great deal more work. The improvements in these machines, and their successful adaptation to Rand conditions, have been effected comparatively recently, but it is hardly possible to exaggerate their importance. The decreased charge of explosives used in the smaller and shorter holes drilled by these machines does not shake or shatter the walls of the stopes nearly as much as did the larger charges that had to be used in the holes drilled by the old heavy rigged machines; in consequence, it has been possible in many cases materially to reduce stoping widths. Furthermore, the machines are so handy that it has also been possible in most cases to use them in substitution of hand hammer work, with a consequent saving of native labour.

Expansion of Operations during Recent Years.—Since the early part of 1922, when operations on the Witwatersrand Gold Field were resumed after the strike, each year has seen some expansion in the scale of operations and a progressive increase in output. Three main causes have contributed to this expansion, namely, an increase in the number and crushing capacities of the mines operating on the Far East Rand, following favourable development in that area, the reduction in working expenses consequent upon the reorganization after the strike, and the tendency of prices and other conditions to return to normal, as the disturbing effects of the late war receded into the past.

Ventilation.—On the Rand, mining at great depth has also necessitated an important alteration in the method of development work. This is now largely carried on well under, and parallel to the ore body instead of on it, in order to ensure that the main workings shall not be interfered with by the gradual but inevitable closing up which follows upon the extraction of the ore. Deep-level mining has also presented other problems to

the responsible engineers, such as the hoisting of rock, and the ventilation of workings. The temperature gradient on the Witwatersrand is fortunately flat, *viz.*, about one degree Fahrenheit for every 300 feet of vertical depth. In ordinary circumstances, the provision of adequate cooling arrangements with such a flat gradient would not present many difficulties. The problem on the Rand, however, is complicated by the presence of silicosis-producing dust, the prevention and suppression of which requires the use of such large quantities of water that the air becomes saturated, and loses much of its cooling value. Consequently, large volumes of fresh air are necessary, and to this end some of the largest ventilating fans in the world have been installed—in many cases at shafts which have been sunk solely for ventilating purposes. A fan capable of supplying 900,000 cubic feet of air per minute was recently erected at a cost of over £155,000 (including the sinking of the ventilating shaft), on the Government Gold Mining Areas, near Brakpan. In addition to the main ventilating fans, subsidiary fans are installed underground to supply the various working places with pure air.

Ore Reduction.—After the ore has been brought to the surface, it is dumped over some form of grizzly for the purpose of separating the large pieces of rock from that which is already sufficiently small to be sent to the mill. The large lumps are passed through a washing device, fed on to conveyor belts, subjected to hand sorting for the purpose of removing waste rock, and delivered to rock breakers, which reduce the lumps to a size suitable for milling. They are then sent to the mill on conveyor belts with the " fines " already separated by the grizzlies.

On most of the mines the first portion of the process of milling is by gravity stamps of the " Californian " or " Nissen " type. These stamps weigh from 1,000 to

[Plate II.] DEVELOPING IN TURF SHAFT, VILLAGE DEEP.

2,000 lb. each, and by being made to fall from 90 to 100 times a minute upon the rock, reduce the latter to the condition of a gravel. On some of the newer plants the ore is reduced to gravel by means of disc and other crushers instead of by stamps. In both cases, however, the gravel, mixed with water, is conveyed into classifiers, for the purpose of separating the ore which has been sufficiently crushed from that which has not. The latter is led into the intake-end of tube mills together with lumps of rock somewhat smaller than a cocoanut, called tube mill pebbles, which have been selected mechanically or by hand before reaching the first rockbreaker. The tube mills are kept about half full of these lumps, which, as the mill revolves, fall upon each other in a cascade-like manner, thereby not only crushing and grinding the finer ore, but also wearing themselves into the same condition. The discharge from the tube mills passes (usually after going over tables covered with corduroy cloth) into classifiers, which return to the tube mills for regrinding that portion of the ore which has not been sufficiently crushed. The ore which has been sufficiently crushed, and which is now referred to as pulp, passes as a running stream in launders to the cyanide department.

Gold Recovery.—The details of this process vary somewhat on the different mines. The first operation, however, may be said to begin with the crushed ore leaving the tube mills. Formerly this ore was passed over amalgamated copper plates so as to bring any free gold into contact with mercury, which amalgamated with it. These plates were periodically scraped so as to remove the gold amalgam. There were, however, several objections to this system, and, for some time, corduroy cloth has been substituted for the amalgam plates. The crushed ore, in flowing over this material, leaves behind it most of its free gold, as well as some of its heavier gold-bearing minerals. The cloths are periodically taken up and suitably washed so as to obtain the gold and

other concentrates. The washings or, as they are called, black sands, are passed over a shaking, concentrating table which separates the gold and richer portions of the concentrates from such ordinary sand as is unavoidably also caught by the corduroy cloth. The gold and cleaned concentrates are ground in amalgam barrels and mixed with mercury for the purpose of recovering such gold as will amalgamate with it. The mercury is recovered in a batea or pan, cleaned, pressed through amalgam cloth to obtain the gold amalgam, and re-used. The gold amalgam is periodically retorted, and the resulting sponge gold is melted into bars and sent to the Rand Refinery.

The ground black sands which, in a number of cases, contain appreciable quantities of osmiridium, are treated in various ways, and ultimately sent to the mines' co-operative smelting works for further treatment.

The pulp finally leaving the tube mills consists of sand and slime. On some mines the sand is ground to such a fine condition that it is treated as slime, but on those mines where the sand is less finely ground it is treated separately. The essential features of the treatment, however, are the same in both cases, and consist in first removing the excess water* used in the milling process, and then bringing the pulp, sand or slime, as the case may be, into intimate and somewhat prolonged contact with weak cyanide of sodium solutions. These solutions dissolve practically all the gold which is exposed to their action. The gold-bearing solutions are then dissociated from the treated ore by suctional or gravitational filtration. They are then brought into intimate association with zinc, either in the form of finely cut shavings or dust. The chemical action resulting from this association causes the formation of a precipitate containing the gold. The solutions are made up to

*In a few cases, the milling is done in cyanide solutions.

strength and re-used, and the precipitates are recovered by suitably washing the zinc shavings and forcing the solutions in which they are suspended through a filter press. They are then treated with acids and hot water to remove excess of zinc and other base metals which may also have been precipitated, then dried, calcined and smelted so as to obtain the gold in metallic form. This gold is then smelted into bars and sent to the Rand Refinery.

The treated pulp, sand or slime, as the case may be, is discharged from the treatment tanks and pumped, or otherwise conveyed, to what are known as slimes dams or tailings dumps, which are now such conspicuous landmarks on the Witwatersrand.

Some Statistical Points.—From the discovery of the field until the present day, the Gold Mining Industry on the Rand has treated over 700,000,000 tons of rock, from which gold valued at £970,000,000 has been extracted. In the Province of the Transvaal, gold valued at over £1,000,000,000 has been produced since 1885. Historical statistics of production are usually dated back, as shown in Dr. Soetbeer's tables, to the year 1493. According to these tables, the gold produced in the Transvaal since 1885 is over one-fifth of the world's total gold production during the period from 1493 to 1928.

At the present time the labour force on the Rand numbers approximately 22,000 Europeans, and 200,000 natives. In addition to the amounts of direct and indirect tax revenue, which the Government derives from the Gold Mining Companies, their employees and others dependent on the industry, the Government shares in the profits of certain companies to the extent of about £2,500,000 per annum. The livelihood of a quarter of a million Europeans and a million natives throughout the Union is traceable, directly or otherwise, to the Witwatersrand Gold Mines. The Industry is historically

responsible for the high rate of wages paid in South Africa to European skilled labour, and is still the mainstay of these rates.

During the year 1928, the companies producing gold on the Rand treated 30,045,100 tons of ore, and extracted therefrom 9,840,698 ounces of gold. The working revenue of the companies was £42,039,869, and the working costs £29,598,151 ; working profit amounted to £12,441,718, from which, after payment of taxation and the Government share of profits, dividends amounting to £7,980,095 were paid. The revenue, costs, and profits amounted respectively to 28s., 19s. 9d., and 8s. 3d. per ton ; the sum paid in wages amounted to about £14,500,000, of which almost £8,000,000 was paid to Europeans.

Conclusion.—Very briefly, the foregoing represents a review of the Witwatersrand Gold Mining Industry, and apart from the geological features of the Field, visitors will, no doubt, be interested in the magnitude of the equipment erected along the Reef for the hoisting and treatment of the ore, the huge power stations which supply the mines with electricity, the Rand Refinery, which handles approximately 55 per cent. of the current gold output of the world, the Native Compounds, wherein 200,000 coloured labourers are housed and fed under conditions which are generally agreed to leave little to be desired, and many other aspects and phases of the Industry.

Plate 15.] LARGE STOPE SHOWING CONCRETE PILLARS.

VII.

DIAMONDS.

By ALEX. L. Du TOIT, B.A. D.Sc.

Introduction.—Of the great businesses of the world, there is none so enveloped in romance as the Diamond Industry of South Africa. The glamour of the East, which attaches to these peerless gems, appears to have survived in this materialistic age, and these glittering bits of crystallized carbon seem to be as ardently sought to-day as ever. That such is the case has, indeed, been providential for the Union of South Africa, the prosperity of which has so largely depended upon the myriads of diamonds laboriously extracted by mining companies and by individual diggers from the vast stores provided by Nature. This will be appreciated from the fact that the total value of the precious stones recovered up to the end of 1927 in the Union and South-West Africa is computed at the colossal figure of 320 millions sterling.

The momentous discovery of the first diamond in 1867, a romantic tale that needs no repetition, led to the more far-reaching finds of the gem in gravels at Klip Drift (now Barkly West) and Pniel and to the establishment of the "River Diggings" of Griqualand West. Epoch-making was the finding of the gem at Jagersfontein in the Orange Free State in 1870 in a deposit of an entirely different kind, for the wave of prospecting that resulted therefrom led to the discovery, in 1871, of similar occurrences on the farms Du Toits Pan, Bultfontein and Vooruitzicht (where Kimberley now stands), and, incidentally, to the founding of an industry destined to grow to immense proportions.

The new " Dry Diggings," so styled in contrast to the " Wet Diggings " fronting the Vaal River, served, as they were developed, to confute not only lay, but also scientific, opinion by proving to be the worn-down stumps of ancient volcanos, the throats of which had been filled from below with a unique type of eruptive material in which the diamond lay embedded.

Under the existing mining regulations, each digger was entitled to peg off a claim of 30 by 30 Cape feet, and every mine was accordingly blocked out in chequer-board fashion ; the multitude of claims of individual owners, syndicates or companies were worked independently and at varying rates in a manner identical with that now conducted, nearly half a century later at Lichtenburg, as depicted in the illustration of the Grasfontein diggings. Despite the great difficulties pertaining to that system, surprising depths were reached, but ultimately the situation became impossible. The problem was only solved through the bringing together of the diverse interests under the single control of the De Beers Consolidated Mines. With that far-sighted amalgamation of 1888, there will ever be associated the name of our empire-builder, Cecil J. Rhodes.

In 1893 was formed the London Diamond Buying Syndicate, a powerful organization that has not only handled the bulk of the stones produced, but has tided the industry over critical periods, such as in 1907-8, in 1913-4 and so late as in 1926-8.

In 1896, the only other important mines away from Kimberley were the Jagersfontein and the Lace (now the Crown), but others were opened up a few years later, for instance, Koffyfontein, discovered in 1893, Frank Smith in 1900, Premier in 1902 and Voorspoed and Roberts Victor in 1906, together with several smaller ones, most of which are to-day closed down. It is curious

to note that for more than a quarter of a century, no new pipe of importance has been discovered.

Of the many productive mines that have been worked at one time or another, scarcely a dozen are in operation to-day. This is not on account of adverse mining conditions, but, in the main, because of the continued large output from other sources, the chief of which are the Alluvial Fields of the Union and of South-West Africa.

In 1908, the sandy wastes of the coast near Luderitz disclosed their store of wind-sown riches; the ground was secured by a number of German companies, and at the outbreak of the Great War, diamonds to the value of eight and a half millions sterling had been obtained by those concerns. In 1920, an important amalgamation of interests was effected under the title of the Consolidated Diamond Fields of S.W. Africa, under which it became possible to exploit these wide-spread deposits in a far more efficient manner.

The years 1926-7 saw the spectacular rise of the Alluvial Fields of the South-Western Transvaal. Thousands of people took part in the various " rushes." An enormous population collected from all parts of the country, and diamonds were extracted on an unprecedented scale.

Early in 1927, the incredibly rich deposits in Namaqualand were found, as the result of scientific prospecting, and in 1928 the Union Government proceeded to work, as a State Diggings, those portions upon Crown Land not granted to the several discoverers. From that date the Union Government entered the ranks of the great producers of the World's diamonds.

Output.—Owing not so much to purely economic causes, as to influences which could not be foreseen or frustrated, production has varied enormously in different years, though some of the more serious fluctuations were

counteracted by the efforts of the Diamond Buying Syndicate. No records are available for the Orange Free State prior to 1904, and the following figures are, in this measure, incomplete. To the end of 1927, the yield has been for the Cape, 97,884,746 carats; Transvaal, 30,695,132; Orange Free State, 8,609,334; S.W. Africa, 10,348,033; with corresponding values of £193,782,031; £48,382,600; £24,629,200 and £24,127,727. This gives a total of 147,537,245 carats, worth £290,921,558. Altogether, South Africa will have produced to the end of 1928 diamonds to the value of about 320 millions sterling. The World's production for 1927 is estimated at 7·4 million carats, worth almost 17 millions sterling, of which South Africa, with a return of 5,377,600 carats valued at £14,127,600, contributed no less than 83·2 per cent.

The Diamond Pipes. *General.*—The number of these remarkable volcanic necks or chimneys filled with eruptive matter continues to mount; probably several hundred are known, dotted over quite a large proportion of the sub-continent, from the centre of the Karroo northwards into the Congo and Tanganyika, and from East Griqualand to the centre of S.W. Africa, while each year finds new ones recorded further afield. There is a marked tendency for them to occur in clusters, and not infrequently the discovery of one leads to the finding of a second or third in the vicinity. Of the multitude, the vast majority have been found to be barren, or the diamond is present in them only in insignificant amount. It cannot, however, be doubted that many other pipes await discovery, some of which may be found productive, thereby extending the life of the industry.

In the early stages of opening up the "dry diggings," the true nature of these strange occurrences was by no means obvious, and even to-day it is only by inspecting the huge excavations walled in by solid rock, that one can realize that the material is being drawn from the

tops of eruptive columns rooted deeply in the Earth's crust. They represent the stumps of ancient volcanos of a kind not known in active eruption anywhere to-day.

Size and Shape.—Ranging from tiny perforations, less than one hundred feet across to the gigantic Premier with a larger diameter of over half a mile, these pipes are circular, oval or somewhat irregular in cross-section, and may show remarkable variations in outline with depth. Indeed, in this respect they may be far removed from the regular tubular perforations that one is led to associate with volcanos in general.

The Kimberley Mine, which at 340 feet was an oval 820 by 500 feet, contracted at 2,160 feet to a width of only 250 feet, while further down it moved bodily eastwards. It was there discovered to be sending out a long dyke-like tongue in a north-westerly direction towards the little St. Augustine's Mine, which itself at 800 feet became a wide " fissure " striking towards the Kimberley Mine. The De Beers Mine exhibits extraordinary variations in its outlines. At 2,040 feet, it is in plan like a J ; between 1,900 and 1,800 feet, it is definitely a double pipe united by a neck only 50 feet wide ; at 1,700 feet, it becomes an oval 760 feet long and 150 feet broad at its narrowest part, but above 1,000 feet it is no less than 400 feet wide and 960 feet long. The Dutoitspan Mine shows equally startling changes in outline, and in depth discloses dyke-like prolongations at either end. The Frank Smith Mine is a particularly fine instance of a twin-pipe united by an extremely narrow portion, and is dumb-bell shaped in plan. These extinct volcanic throats which are being disinterred, are sheer marvels of nature.

Contents.—Beneath the surface soil or limestone, the workings disclosed a yellowish friable material known as " Yellow ground", which at lower levels was found to pass into a harder bluish rock that was termed " Blue

ground"; the former was discovered to be merely the weathered form of the latter; with depth the colour became a dark bluish-green.

To this extraordinary eruptive rock the very appropriate name of " Kimberlite " was given by Carvell Lewis; it is quite unlike any other rock. It is low in silica and high in magnesia, and hence belongs to the ultra-basic class and has a fine-grained matrix through which are scattered crystals and irregular granules of various minerals rich in magnesia such as olivine, enstatite, diopside, brown mica and also of garnet and ilmenite. More striking is the abundance of foreign matter of both igneous and sedimentary origin, distributed irregularly, from microscopic particles to masses of enormous size, the kimberlite resembling in this respect the agglomerates of volcanos, ancient and modern. These fragments represent material torn from the walls of the perforation, as the latter was progressively enlarged, and incorporated in the molten magma during its ascent. The larger bodies are known as " floating-reef", of which the most striking example is the conspicuous mass occupying the east-central portion of the Premier Mine, a gigantic slab of reddish quartzite and conglomerate, nearly half a mile in length, tilted to a high angle in the enclosing eruptive matter. More remarkable still is the fact that this huge block has been derived not from the adjacent formations, but from strata that formerly overlay the region and was pierced by the pipe, since stripped from the vicinity by erosion. These pipes may, indeed, be likened to museums, for in them have been preserved fragments of now-vanished formations as well as samples of rocks existing only at enormous depths.

The coarsely crystalline inclusions of ultra-basic rocks of striking appearance are of deep-seated origin; they are composed of various combinations of the minerals olivine, enstatite, diopside, mica, garnet and ilmenite

Plate [illegible] ALLUVIAL DIGGINGS ON GRASFONTEIN, L. LICHTENBURG, TRANSVAAL. AUGUST, 1927.

known as lherzolite, hartzburgite, eclogite and so on, and occur as oval, pitted " boulders " in the blue ground. From the shattering of such types, many of the fragments of those minerals in the kimberlite have been derived. Irregular pieces of chrome-diopside, garnet and ilmenite, a few pounds in weight, have now and again been recovered in mining.

Scientifically, these blocks are of enormous interest, as they indicate the presence, predicted by theory, of a high-density, ferro-magnesian zone situated beneath the shell of granitic and gneissic rocks underlying the sedimentary outer crust. The minerals are the same as those that have crystallized within the purer varieties of kimberlite, which suggests that the eruptive matter was largely derived from the fusion, at a depth of probably many miles, of rocks of such kinds as compose the Earth's ultra-basic shell. In its rise, at first through narrow fissures and thereafter explosively through chimneys, the molten matter brought along with it fragments from and above the level of fusion and incorporated blocks from the formations pierced at higher levels. Immense interest, therefore, attaches to these strange conduits.

Kimberlite itself varies greatly in its appearance and composition, not only in the different occurrences, but quite as frequently in different parts of one mine, a feature due largely to the variable proportion of included foreign matter. Some varieties are so crowded with inclusions that they can be termed breccias, others again are relatively clean, although it is hard to get specimens devoid of foreign particles. The bulk of the kimberlites are of a " basaltic " habit and have mica subordinate, but there is also a class with abundant bronzy phlogopite mica, which type is practically non-diamondiferous.

A remarkable property is possessed by most blue ground, namely that of disintegrating when left exposed to the atmosphere for some time, but there are varieties

which fail to do so, or in which such action is slow or imperfect. These types are known as " hardebank," which generally looks fresher and has a dark colour. Patches of hardebank occur in every mine, but in certain pipes the bulk of the kimberlite is of this resistant character, a matter of practical importance, since the rock is then too hard for treatment, although it may be as rich in diamonds as the adjacent " soft blue".

The Producing Mines. *The Premier Mine*, situated to the east of Pretoria, is well named ; it is 2,900 feet in length and about 1,400 feet across, and has an area of 3,570 claims (each 31 by 31 feet), though the huge mass of floating-reef cuts down the mineable area considerably. The accompanying view shows the western side of this stupendous excavation with its vertical walls of intensely hard rock (felsite), against which is an immense buttress of blue ground left in to protect the main haulage incline. The deepest working shown in the photograph is 460 feet from the surface, but the 610-foot level has just been started, and it is intended before long to do some of the mining underground ; at present all the work is opencast. During 26 years, the volume of rock extracted has been colossal ; up to October, 1928, over 135 million loads (each weighing about 1,600 lb.) have been washed, from which nearly 27 million carats of diamonds have been recovered.

Dutoitspan at Kimberley is next in size ; it is very elongated, being about 2,200 feet in length, and is probably a multiple pipe. A mass of poor ground, apparently the product of an earlier eruptive phase, occupies the central portion. The lowest workings are at 1,350 feet.

Wesselton has nearly the same size and becomes elongated below 1,000 feet, while *Bultfontein*, close by, is pear-shaped in plan at the surface, but has shrunk somewhat in depth. This and the *Wesselton* have been opened down to the 1,600 foot level.

Koffyfontein and *Jagersfontein* in the Orange Free State are somewhat larger, almost similar in their size and shape, with a mean diameter of about 1,250 feet. The former is still worked opencast at 330 feet; the latter is being mined by underground methods down to 1,000 feet.

The *De Beers Mine* has a length of 760 feet and a breadth of 480 feet at the 800-foot level, but the blue ground on its north-western side is poor and has not been worked. The workings have reached a depth of 2,040 feet, but operations are at present suspended.

In the *Kimberley Mine*, which has also been idle since 1914, the column of blue ground has been proved to the prodigious depth of 3,600 feet, the values still being high.

The *Crown* (or *Lace*) Mine near Kroonstad, the *Phoenix*, near Theunissen, *West End*, at Postmasburg, *New Elands*, near Boshof, and the *Frank Smith*, near Barkly West are other important producers.

The Diamond.—The stones recovered range from microscopic individuals up to crystals several hundreds of carats* in weight ; the largest on record is the renowned Cullinan Diamond, found at the Premier Mine in 1905, which weighed 3,025¾ carats (nearly twenty ounces troy) and was only a portion of a much larger crystal. South Africa's contribution to the large jewels of the World has been considerable, *e.g.*, the Excelsior, Jubilee, Victoria, Tiffany and Stewart (obtained from the Vaal River gravels), the four last of which, after cutting, weighed 239, 228, 125 and 120 carats respectively.

They occur chiefly as octahedra (eight-sided), rhombic-dodecahedra (twelve-sided), and a few other regular forms belonging to the cubic system, outstanding among other characteristics being the strong curvature of

*A metric carat is equivalent to 200 milligrammes.

some of the faces, a curious rounding of certain of the edges and the presence of microscopic inverted triangles on the octahedral faces. Flat, twinned crystals called macles are fairly frequent, also flattened and distorted stones, a fair proportion of broken ones (called cleavage) and impure and imperfectly crystallized material known as bort and not of gem quality. Some remarkable freaks come to light from time to time, such as pitted stones, intergrowths, cases of one diamond enclosing or else moulded upon another, zonal crystals, coated stones, crystals with inclusions, which provide much information regarding the crystallization of this mineral. In colour there are all gradations from the rather rare and much valued "blue-white", through white, yellow to brown, and even blackish stones. The diamonds recovered from kimberlite are on the whole of a lower quality than those obtained from the alluvial deposits.

Origin of the Gem.—The kimberlite occurrences have shed a flood of light upon this fascinating problem, which is, nevertheless, by no means simple. The gem is found embedded in the blue-ground just like the associated mineral and rock fragments, and, as these crystals are not infrequently broken, they might reasonably be regarded as having been derived from deep-seated ancient rocks. Indeed, the diamond has actually been found crystallized within the garnet of an eclogite rock, as a primary constituent. It is, however, considered that the latter represents one special mode of formation, and that the bulk of the diamonds crystallized out in the kimberlite magma either in depth and prior to the rise of the latter in the pipe, or during its ascent. This is borne out by the striking differences often shown between the stones obtained from different mines, which are usually so marked as to enable experts to identify separate parcels without difficulty.

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A CORNER OF THE PREMIER DIAMOND MINE.

As regards the source of the carbon, only a small proportion of that element would be required, and this might well have been furnished by carbonic acid, such as is known to occur in all igneous rocks and is present, in combination as calcite, in all kimberlites, even when obtained from the greatest depths.

Diamond Mining ; *Methods of Working and Recovery.* The extension of open mining to greater depths leads to various troubles and accidents, so that ultimately it becomes necessary that all work be conducted underground. Although 600 feet down in its deepest part, the huge Premier is still working opencast, largely because of the solidity of its walls, and the blue-ground is brought to the surface by means of the long, inclined haulage so conspicuous a feature within this gigantic excavation. Koffyfontein and some of the smaller mines are being exploited in similar fashion. At other important mines no obvious sign of subterranean activity can be seen from the edge of the excavation, but, out of sight, the blue-ground is being removed in a series of slices by an admirably planned method of chambering until the overlying mass of waste ground (" reef ") invades the workings. The broken rock is removed through levels, or is shot down " rock passes", and thence taken to the main shaft some distance away from the pipe, and brought to the surface. Under the old system the broken rock was spread out over immense " floors " and allowed to lie for months to disintegrate and release the gems. To-day the rock is passed directly through a series of crushers and rollers during which process the bulk of the foreign matter is removed ; the small fraction thus separated contains the denser minerals and rock fragments together with the diamonds, which have a density of 3·5. These "concentrates " proceed to the Pulsator, where, after having been screened and sized, it is put though jigs with further removal of the lighter material. The heavy fraction is fed on to vibrating, sloping tables coated with grease, to

which the diamonds adhere, while the flowing water carries away the dross. A million cubic feet of loose blue ground weighs about 50,000 short tons, and, depending on the particular mine, yields between 600 and 1,400 carats (2½ to 6 lb.) of diamonds, which represents a concentration of from 1 in 38 to 1 in 16 millions.

Costs.—During 1927-8, 14 million loads were treated by the mines, equivalent to a cube about 200 yards to the side, and gems weighing 1,000 lb. were recovered. This does not represent their full activities, since a considerable proportion of barren rock had also to be mined and hauled to the surface. The large scale of operations has, however, enabled costs to be kept at a low figure, which in the case of the Premier is just under 2s. 6d. per load washed, while in the De Beers group, where the working is underground to depths of 1,600 feet, the figure is 4s. 9d., of which 1s. 8d. represents the cost of treatment.

Labour.—The average number of persons employed on the mines during 1927 was 3,049 whites and 17,664 natives. In order to prevent thefts and also to secure the highest efficiency, the " compound " system has been essential, under which there is a rigid confinement of natives to enclosed compounds during non-working hours. In spite of this, and partly because of good treatment, coupled with the provision of a scale of rewards for all diamonds picked up during work, there has at all times been a plentiful supply of labour presenting itself and recruiting has been unnecessary. On the Alluvial Fields there are no such restrictions and most of the natives are obtained locally. During the boom of 1926-7 native wages stood at the high figure of £1 per week (without rations), but has since dropped to 15s. The average number of persons employed in the diamond industry in the Union during 1927 was 11,589 whites and 43,259 natives, and of these over 80 per cent. were in the

Transvaal. In S.W. Africa, it has been necessary to recruit labour from Ovampoland or Bechuanaland; in 1927 the average number employed by the Consolidated Diamonds was 530 whites and 4,700 natives.

The Alluvial Fields.—*General.*—The history of development of the various fields strung out along the Vaal River has been most fascinating. Vast indeed are the wastes dotted by mounds of pebbles, a testimony to the activities of the digger and of his struggles to wrest the treasure stored in Nature's hoard. More than half a century has elapsed since the sensational discovery of diamonds drew crowds to Griqualand West, and, though the older fields have long passed their zenith, digging still goes on there, although the returns of such effort are, on the whole, precarious. To-day the chief output is from the deposits of Lichtenburg and Ventersdorp and from those on the Atlantic sea-board. The following few selected years will serve to show the scale of such operations in the Union, and also the tremendous increase, caused mainly by unrestricted production in the South-Western Transvaal:

Year	Output in metric Carats	Total Value	Average price per Carat	Labour Employed:	
				Whites	Natives
1913	206,049	£1,120,227	108/9	4,602	16,194
1922	203,925	£1,359,628	133/4	5,191	15,855
1926	808,329	£3,983,681	98/7	11,842	39,740
1927	2,318,407	£6,198,769	55/7	11,589	43,259

Alluvial diamonds are, as a rule, markedly superior, obtaining from 2 to 4 times the price got for mine stones on an average. There has been much discussion as to the origin of the gems in the river diggings, but there can be little doubt that they have been derived in the main from

kimberlite pipes during the gradual wearing down of the land surface. Indeed, in any group of diggings, it is often possible to pick out from among the stones quite a fair proportion that can be referred with little or no hesitation to certain pipes in the neighbourhood.

The Alluvials of the Vaal and Orange Rivers.—During a period representing many thousands of years, this great drainage system has been deepening its channels and leaving on various levels patches of boulders and pebbles to mark the limits of its former floods. These gravels stand to-day at heights ranging up to as much as 200 or even 300 feet above the present rivers, and are sometimes situated miles away from any drainage courses. In addition to the more abundant and wide-spread surface gravels, from a foot to several feet in depth, which are loose and easily worked, one finds also the rarer " deep-gravels", which are really stiff conglomerates representing river-beds and occupying steep-sided channels cut in the bedrock. They may occasionally be 50 or more feet in depth, as at Waldeck's Plant or Droogeveld, near Barkly West, and have occasionally been mined by underground methods, since the rich portions are usually at the very bottom. The shingle occupying the present river channels may also carry diamonds, and is sometimes worked by the building of breakwaters during the dry season. In spite of the risks involved, some surprisingly large and costly diversion schemes have been carried out from time to time, usually with considerable profit.

Though gravel terraces occur extensively along the Orange River, it so happens that the pebbles have mostly been cemented by carbonate of lime into a hard mass, and, consequently, there are but few diggings below the junction with the Vaal.

The operations of " digging " are simple. The large boulders are picked out by hand, the smaller ones removed by screening, and the remainder is stirred up with water

Plate 18.] "GREASE TABLES" AT THE DE BEERS PULSATOR, KIMBERLEY.

in a rotary pan; the heavier fraction so separated is concentrated further on a sieve in a barrel of water. Among the boulders of various rocks are found water-worn striped pebbles known as "bantoms", agates, rare garnets, and in exceedingly small proportion the diamond, many of the crystals showing in their abraded edges proof of transport and wear.

Lichtenburg and Ventersdorp.—The tracing of the Vaal River gravels towards the north-east led to the finding of these ancient alluvials, to the proclamation of farm after farm and to a series of "rushes" of a kind unprecedented in history, culminating in the famous charge on Grasfontein in March, 1927, in which some 25,000 runners took part in their efforts to secure a claim. Small townships sprang up with mushroom-like rapidity, and it was estimated that during August, 1926, over 56,000 natives were being employed.

The gravels consist of water-worn pebbles with much angular chert derived from the supporting dolomite, having a reddish or yellowish clayey matrix in depth. These deposits of former rivers owe their preservation to sub-surface solution of the dolomite, whereby the gravel subsided into cavities formed in the latter. Astonishing thicknesses have been found, 30 to 50 feet being sometimes sectioned, while in certain sink-holes (called "pot-holes"), walled in by dolomite, depths of over 100 feet have occasionally been recorded. The illustration of the Grasfontein diggings gives an idea of the nature of the material and of the methods of extraction. The concentrated effort of thousands of diggers led to the increase of the output from 7,322 carats in May, 1926, to 114,579 in October, to 172,084 in February, 1927, and to 229,237 (the maximum) in April. In 1926-8, the South-western Transvaal produced over 4 million carats to the value of nearly 11½ millions sterling.

South-West Africa.—The inhospitable coast near Luderitz is made by ridges of bare rock jutting through gritty sand, which, swept by strong winds lies piled up in creamy dunes. The opening up of this waterless waste in 1908-12 presented enormous difficulties, which were skilfully overcome by German enterprise. The majority of the interests were, in 1920, amalgamated under the control of the Consolidated Diamonds of S.W. Africa, which has developed the fields by the most up-to-date methods. The output of this Company is almost half a million carats annually and the average price 58s. per carat.

Within a stretch extending down the coast for about 75 miles, and inland for from 5 to 8 miles, are patches of sand carrying coarser particles of quartz, agate, chalcedony, garnet, etc. By removing the finer particles, the wind has gradually brought about a concentration of the coarser material together with the diamond, and the latter is usually found near, or at, the surface, especially on the crests of little waves; in places the degree of enrichment has been remarkable. In the early days this concentrated layer was worked by hand-picking and by dry-sifting, but to-day elaborate plants are in existence and huge volumes of lower grade material can be treated at a profit.

While the diamonds are on the whole small (from 0·15 to 0·25 of a carat); they are of exceptional quality, and the proportion of cleavage and inferior stones is low. At Conception Bay, far up the coast, diamonds are being recovered under similar conditions.

Namaqualand.—More astounding yet are the fabulously rich deposits near the mouths of the Orange and Buffels Rivers, which represent portions of ancient raised-beaches, which were formed by the waves, when the land stood anything up to 200 feet lower relatively to the ocean, as shown by the presence of oyster and other

shells between the worn boulders, pebbles and sand. The diamonds occur mainly in the basal portion of this old shingle, particularly under boulders or in hollows in the worn surface of the rocks beneath. While the richness of certain portions of these shingles is almost incredible, it must be pointed out that such deposits are relics that have survived erosion, that in places they are surprisingly narrow, and that they may pass abruptly into barren shingle. Much of this coastline is covered by sand, and elaborate prospecting may be necessary to follow up these ancient beaches. Diamonds have been found at intervals from a point just north of the Orange River southwards to the Groen River.

The stones are of remarkable quality and often of good size, with the high value of up to £12 per carat, cleavage and inferior classes forming only a small proportion. The output of the Alexander Bay area has not yet been made public, but there can be no doubt that over ten million pounds worth of gems have already been extracted. Excluding certain discovery rights, the remainder of the Crown reserve is being held and worked by the Government as a State Diggings. Opinions differ as to the source of the diamonds in both Namaqualand and S.W. Africa, inasmuch as certain classes of stones are not represented in the product of the mines or the Vaal River alluvials. Undoubtedly the ocean has played a most important part in their distribution and concentration, but their prime source remains obscure, and its search constitutes a fascinating problem.

Economics.—There has been an undue number of ups and downs in the life of the industry, for instance, the two wars and the various disconcerting discoveries of new fields, such as those in S.W. Africa, which attained their zenith in 1913-14, and the diggings of Lichtenburg and Ventersdorp, which at their maximum during 1927,

poured forth stones to the value of over five million pounds.

Several factors have fortunately tended towards the stabilization and improvement of the price of a commodity, the demand for which is so largely dictated by fashion. Outstanding were the amalgamation of interests at Kimberley, secondly the establishment of the London Diamond Buying Syndicate, and thirdly the policy of voluntary restriction of output to a recognized quota by each of the chief producers, not only in the Union, but also in the Congo and Angola. Nevertheless, great difficulty was experienced in dealing with the flood of diamonds of inferior quality which in 1927 amounted to well over two million carats; it is significant, however, that the price of diamonds did not fall much in 1928 despite the vast number of high grade stones extracted in Namaqualand. To-day the Union Government is not only a taxing body with a large share in the output of the Premier and Phoenix mines, but is itself a producer on an extensive scale.

Proper control of production and unification of interests have undoubtedly led to an appreciable increase in market prices, in which the individual digger and smaller syndicates have shared. Alluvial diamonds are as a rule markedly superior to the average mine stones; in 1913 the price per carat was 108s. 9d. for álluvials as compared with 40s. 5d. for mine stones; 133s. 4d. in 1922 as compared with 39s. 1d., but in 1927 the figures were almost equal, on account of over-production from Lichtenburg, coupled with the inferior quality of that product. This is shown by the fact that in 1927 the average price of the Transvaal alluvial stones was only 47s. 9d., whereas that of the Cape alluvials stood as high as 149s. 3d., as compared with 55s. 10d. for mine stones.

Owing to their small average size, the S.W. African diamonds only command 58s. per carat, but the particularly fine gems of Namaqualand have brought from 150s. to 250s.

Legislation.—Save in the case of a few farms protected by original titles all precious stones are the property of the State, but can be sought for and extracted under cover of various mining acts and regulations. Formerly, the discovery of a payable alluvial deposit led automatically to the proclamation of the ground as a public diggings after the owner and discoverer had selected the claims to which they were entitled. The opening up of the enormous deposits in the S.W. Transvaal with consequent over-production necessitated amending legislation, met by the far-reaching Act No. 44 of 1927, which conferred upon the Government extraordinary powers in respect of the granting or prohibiting of prospecting on private, as well as on Crown, lands, in the working of such deposits, and in the disposal of the diamonds won.

For a monthly payment of 5s., a digger is permitted to peg and work a claim on any proclaimed Diggings with full right to all the finds thereon. Under a drastic clause of the new Act, syndicates and companies cannot operate on such fields except by right of original ownership or discovery.

In the case of a mine, save for various existing concerns, the Government retains the right to one-half, if situated on private, or seven-tenths, if on Crown land. The State holds a six-tenths interest in the Premier Mine.

In Namaqualand the Government retains full possession of all diamonds on Crown reserves, excepting over the several discovery rights which have been granted, and the fields are being operated as a State Diggings.

In S.W. Africa the situation is complicated because of various rights acquired prior to the Great War. Within the "Sperrgebiet", a huge tract running back some 60

miles from the coast and extending from the Orange River to well north of Luderitz, the diamonds are (with some small reservations) the property of the Consolidated Diamonds, Ltd., subject to the payment of a royalty upon production. Over the rest of this mandated territory, prospecting is governed by regulation.

Taxation.—Since 1919, an export tax of ten per cent. on rough diamonds has been in force with the ostensible object of encouraging a local cutting industry. The Government holds an interest in the Premier to the extent of 60 per cent., and also one in the small Phoenix Mine, otherwise revenue is obtained through Profits Tax, which amounts to 3s. in the pound, or 15 per cent., in addition to the 10 per cent. Export Duty.

In S.W. Africa the Diamond Tax is fixed at 66 per cent. of the value of the production, less 70 per cent. of the working expenses, and under this heading the Consolidated Diamonds, Ltd., have paid during the past eight years an average of £280,000 per annum.

Diamond Cutting.—Cutting has been done on only a very limited scale in South Africa, the rough stones being exported, mainly to Amsterdam and Antwerp. Late in 1928, under a Government subsidy, and with certain concessions, the South African Diamond Cutting Association was established at Kimberley, while the Kimberley Diamond Cutting Factory has just been completed, and should ultimately employ a large number of workers. During 1928 the number of establishments was 11, with 14 licensed cutters and 80 apprentices. The desirability of establishing a large cutting industry within the country which produces the diamonds has long been conceded, and was, indeed, recommended by a Select Committee of the House of Assembly in 1913, but it should be remembered that the enormous industry in Europe has been built up over many years, and the important side of marketing the finished product must be taken into con-

sideration. Against the remission of the 10 per cent. export tax on rough stones must be set the higher wages to be paid in South Africa.

Future of Diamond Mining.—It can confidently be asserted that for many years South Africa will be able to supply the World's demand for diamonds, which is equivalent to about fifteen millions sterling per annum.

Taking merely the three Kimberley mines in operation to-day, there are in sight above the 1,600 foot level 93 million loads of blue-ground, which can be expected to yield 20¾ million carats. The giant Premier Mine has only reached 600 feet in its deepest part and must have a vast store locked up, though the average quality is distinctly poor. The Transvaal alluvials will continue to produce for many years, but capital will be needed to work the deeper gravels on a large scale. The fields in S.W. Africa are far from being exhausted, and there are large areas to which little attention has so far been paid. The wonderful terraces along the Atlantic contain diamonds of unprecedented quality, and the potentialities of this lengthy region can as yet only dimly be visualized. There is no doubt that this desert strip will, over a period of years, produce an enormous number of high class stones of the quality so greatly in demand. The reserves of diamondiferous gravels in the Congo and Angola are great, and no one can foresee what new discoveries remain to be made.

In 1927, all sources outside Africa supplied only 6·4 per cent. of the world's production, while the share of the Union and S.W. Africa together was no less than 83·2 per cent.

The State obtains revenue to the extent of 10 per cent. through export tax and also through Income Tax as well as in various indirect ways; it will, therefore, be realized that the prosperity of the Union is closely bound up with that of the Diamond Industry, and due consideration should be given to its welfare.

VIII.

MINERALS AND MINERAL PRODUCTS, OTHER THAN GOLD AND DIAMONDS.

By PERCY A. WAGNER, D.Sc., D.Eng., F.G.S.

Introduction.—South Africa* has been lavishly endowed by nature with mineral wealth.

In addition to gold and diamonds, she is the leading producer of chromite, osmiridium and corundum, the second largest producer of asbestos, an important producer of coal, platinum, silver, copper, tin, iron and salt, and an important prospective producer of manganese ore.

Less important mineral products, actual and potential, include " white " arsenic, antimony, pyrite, nickel, tungsten ore, lead, uranium and radium ore, fluorspar, graphite, mica, barytes, magnesite, talc, soda, gypsum, mineral paints, building and ornamental stones, clays of various kinds, limestone and dolomite, oil shale, phosphates, kieselguhr, glass and other sands, natural gas, amethyst and emeralds.

These several metals, minerals and mineral products may briefly be dealt with in the order in which they are enumerated.

Chromite.—As already stated, South Africa is the principal source of this very important mineral. The major portion of the output is derived from the deposits of Southern Rhodesia, but the Transvaal is also becoming an important source of production.

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*For purposes of the present chapter South Africa is taken to include the Union and Southern Rhodesia.

THICK SEAM OF CHROMITE ROCK OVERLAIN BY ANORTHOSITE. GROOTBOOM NO. 186, LYDENBURG DISTRICT, TRANSVAAL.

Plate 19.]

The chromite mined in Rhodesia is mostly of high grade, which means that it contains 48 per cent. and over of chromic oxide. Much of it is suitable for the production of ferro-chrome.

The Transvaal chromite is of lower grade, containing from 40 to 46 per cent. of chromic oxide. It is used mainly in the chemical trade, and as a refractory in open-hearth steel furnaces.

Southern Rhodesia.—The Rhodesian output for 1928 amounted to 219,427 long tons, compared with 218,018 tons in 1927. Approximately 59 per cent. of the output was derived from the deposits near Selukwe, 36·8 per cent. from those of the Great Dyke, and 4·5 per cent. from the occurrences on Goddard's Hill near Mashaba in the Victoria district.

In the deposits near Selukwe, chromite occurs in large irregular bodies in talc schist and serpentine, evidently derived from the alteration of a dunitic rock in which the chromite originally formed schlieren and lenses. The ore for the most part is hard and lumpy.

The Great Dyke deposits take the form of thin but very persistent super-imposed, stratiform segregations paralleling the margins of that remarkable intrusion and dipping inward from them at from 10 to 45 degrees. The seams average about six inches in thickness, but in places there are lenticular enlargements up to 24 and even 48 inches in thickness. The chromite is mostly soft and crumbly, but on the whole of higher grade than that of the Selukwe deposits.

At Goddard's Hill chromite occurs in lenses and broken-up stratiform segregations in serpentine derived from dunite. The deposits are relatively unimportant compared with those already dealt with.

Transvaal.—The Transvaal output is derived from great stratiform segregations of chromitite or chromite rock in the lower part of the Norite Zone of the Bushveld

Igneous Complex. The chromitite seams can generally be referred to two or more definite horizons, which have been traced in the Lydenburg and Rustenburg districts for scores of miles. Immense reserves of the mineral are thus available. The seams range in thickness from an inch to 14 feet.

They conform strictly to the pseudo-stratification of the rocks of the Norite Zone, and are, in consequence, inclined at from five degrees to 30 degrees toward the centre of the Complex. The largest and richest deposits are in the Lydenburg district where chromite is at present being mined on the farms Winterveld No. 424, Mooihoek No. 147, Grootboom No. 186, and Grootboom Annex No. 473. There are also important deposits in the Rustenburg district where the mineral is being mined on a large scale on the farm Boekenhoutfontein No. 336.

The Transvaal output for 1928 was 31,327 tons valued at £35,265. That for 1929 is estimated at 50,000 tons.

The following are representative analyses of South African chromite :—

	I.	II.	III.	IV.	V.	VI.
SiO_2	4·48	1·54	6·3	1·82	2·8	5·0
Al_2O_3	16·44	9·40	16·25	6·63	6·12	13·85
Cr_2O_3	50·80	55·44	49·8	46·67	45·63	44·25
Fe_2O_3	1·63	1·78	n.d.	n.d.	n.d.	0·5
FeO	13·40	16·39	15·65	30·01	31·10	26·2
MnO	0·50	0·10	0·4	n.d.	n.d.	n.d.
MgO	9·40	12·72	10·85	14·67	14·21	9·4
CaO	0·60	1·50	nil	n.d.	n.d.	0·15
Na_2O	n.d.	n.d.	n.d.	n.d.	n.d.	trace
P_2O_5	0·04	n.d.	n.d.	n.d.	n.d.	n.d.
SO_3	trace	0·17	n.d.	n.d.	n.d.	n.d.
H_2O+	1·66	0·97	} 0·45			0·15
H_2O-	0·12					
TOTALS	99·07	100·01	99·7	99·80	99·86	99·5

I. Chromite, Rhodesian Chrome Mines, Limited, Selukwe, Southern Rhodesia. Analysis by Messrs. Wallace and Clark, Glasgow.
II. ,, Great Dyke, Southern Rhodesia (probably from the Divide Claims). Analysis by *ibid.*
III. ,, Goddard's Hill, near Mashaba, Victoria district Southern Rhodesia. Analysis by L. Weinberg.
IV. ,, Bushveld Igneous Complex, Winterveld No. 424, Lydenburg district. Analysis by Standard Bank of South Africa, Limited.
V. ,, Bushveld Igneous Complex, Mooihoek No. 147, Lydenburg district. Analysis by *ibid.*
VI. ,, Bushveld Igneous Complex, Kroondal No. 177, Rustenburg district. Analysis by H. G. Weall.

It should be added that at some localities the Bushveld chromite carries notable amounts of platinum.

Osmiridium.—Large amounts of osmiridium are recovered on the Witwatersrand as a by-product of gold mining, the mineral being an original constituent of the gold-bearing conglomerates. It is collected on the corduroy and blanket tables which have replaced the amalgamation plants formerly employed on the Rand mines. What is actually recovered is a concentrate containing a number of minerals among which osmiridium predominates. Notable amounts of platinum and ruthenium are also present. Sales for 1928 amounted to 5,991 ounces valued at £86,921.

Corundum.—The corundum fields of the Transvaal are the richest and most extensive in the world. They cover an area of over 2,000 square miles in the Zoutpansberg and Leydsdorp districts of the Transvaal.

The occurrences are of two main types, namely, (*a*) primary, and (*b*) eluvial.

(*a*) In the primary occurrences corundum in well-shaped crystals and aggregates of interlocking anhedra occurs in irregular vertical intrusions of plumasite pegmatite which, according to A. L. Hall,* are produced

*Memoir No. 15, Geol. Surv. Union of S. Africa.

by the desilication of pegmatitic solutions by reaction with the ultrabasic rocks in which the pegmatites are intrusive. In the Leydsdorp district subsequent magmatic changes under pneumalolytic conditions have resulted in the further conversion of the original plumasite pegmatites into margerite-felspar-corundum rock, for which Hall has proposed the name marundite.

(*b*) The eluvial deposits take the form of extensive, shallow, residual, surface accumulations of corundum crystals ("crystal corundum") accompanied by scattered lumps of corundum-rich corundum-felspar rock ("boulder corundum") derived from the disintegration of bodies of plumasite and marundite.

The output of the Union of South Africa for 1928 was 2,019 tons valued at £12,696. The industry is at present in rather a bad way. If it were reorganized the output could be greatly augmented.

Corundum is also found in the Salisbury and Umtali districts of Southern Rhodesia.

Asbestos.—South Africa has vast asbestos resources, and her deposits contain more varieties of fibre than those of any other country. They are :—

(1) Chrysotile or White Asbestos, cross- and slip-fibre.
(2) Crocidolite or Blue Asbestos.
(3) Amosite or Yellow* Asbestos.
(4) Amosyle.
(5) Tremolite Asbestos.
(6) Asbestic.

At present, South Africa ranks next to Canada as the leading asbestos producer, and though still far behind in point of production, it is probable that the value of her output will ultimately exceed that of Canada.

*This is the trade designation; the colour of amosite is ash-grey.

(1) *Chrysotile*.—Deposits of this, the most valuable variety of asbestos, are widely distributed in the ancient serpentines of the Fundamental Complex. The most important deposits are in Southern Rhodesia, which is now the world's chief producer of spinning fibre, the Canadian output being composed mainly of the shorter grades.

The principal source of production in Southern Rhodesia is the Shabanie Mine, situated in the Belingwe district, which is the most important asbestos mine in the world. Chrysolite asbestos occurs here in a great fibre zone in a body of serpentine derived from olivine dunite. The fibre zone roughly follows the contact between the serpentine and greissose granite intrusive in it. The fibre zone strikes north-west to south-east, and dips to the south-west at 23 degrees. It averages 90 feet in thickness, and carries an average of $3\frac{1}{2}$ per cent. of asbestos. The asbestos, which is of the cross-fibre variety, occurs mostly in parallel veins conforming to the dip of the main fibre zone. The individual veins range in thickness from a fraction of an inch to over three inches. The deposit has been proved over a strike of more than two miles, and to a vertical depth of over 600 feet. Colossal reserves of asbestos are thus assured.

Other important mines in this same body of serpentine are the Nil Desperandum, which adjoins the Shabanie, and the Sphinx.*

There is also a large production of chrysotile asbestos from the Gaths and Kings mines near Mashaba in the Victoria district of Southern Rhodesia.

Chrysotile asbestos of the slip-fibre variety is produced at the Biltong Mine, situated south of Shabanie in the Belingwe district.

*A detailed description of these deposits will be given in a forthcoming bulletin of the Geological Survey of Southern Rhodesia by F. E. Keep.

The Transvaal, too, possesses very important deposits of chrysotile asbestos which are worked at the Amianthus and Munnik Myburgh mines near Kaapsche Hoop, and at the Kalkkloof mine on the farm of that name in the Carolina district.

The spinning fibre of these mines is of even better quality than that of the Rhodesian mines.

(2) *Crocidolite*.—There are vast deposits of this variety of asbestos in the banded ironstones of the Lower Griquatown Series in Griqualand West, and smaller deposits in the basal portion of the Pretoria Series in the Pietersburg and Lydenburg districts of the Transvaal.

(3) *Amosite*.*—Amosite, or iron-amphibole-asbestos, has, so far, only been found in the contact aureole of the Bushveld Igneous Complex of the Transvaal. The most important deposits are in the Lydenburg and Pietersburg districts. The asbestos is of the cross-fibre variety, the fibre being of exceptional length. It is, however, much coarser than either chrysotile or crocidolite and of lower tensile strength, and thus more difficult to spin ; nevertheless, a great future is confidently anticipated for this variety of asbestos.

(4) *Amosyle*.—This is a term applied by prospectors to a silky variety of amosite occurring in the Pietersburg and Zeerust districts. It appears to have better spinning qualities than ordinary amosite. Whether or not it differs in chemical composition from that mineral remains to be ascertained.

(5) *Tremolite Asbestos*.—Tremolite asbestos of the slip-fibre variety occurs, and has been mined, near Pomeroy in Zululand.

**Cf.* Hall, A. L. Memoir No. 12, Geol. Surv., Union of S. Africa.

(6) *Asbestic*.—There is a large deposit of this material, a matted aggregate of fibres of antophyllite, on the farm Korea, situated 50 miles west of Waterpoort Siding in the Zoutpansberg district, Transvaal.

The asbestos production of Southern Rhodesia and the Union during 1928, was as follows :—

Territory.	Variety.	Tons.	Value.
Southern Rhodesia	Chrysotile	39,960	£970,327
Transvaal	Chrysotile	12,162	214,866
Transvaal	Crocidolite	66	2,245
Griqualand West ..	Crocidolite	5,078	113,400
Transvaal	Amosite	6,748	69,039
TOTALS	—	64,014	£1,369,877

Coal.—South Africa is happy in the possession of very large reserves of workable coal. The most important deposits are in the Coal Measure Series (Middle Ecca) of the Karroo System. There are less important seams in the Beaufort and Stormberg beds.

The principal coal fields are situated in the Transvaal, Natal, the Orange Free State and Southern Rhodesia.

Transvaal.—The most important of the Transvaal coal-bearing areas, which are five in number, is the Highveld or Southern Transvaal area, and the most productive coal field within it the Witbank Field. This is at present the chief source of coal production in South Africa. It occupies a considerable area in the southern part of the Witbank district. There are five, and in places six, distinct seams lying horizontally above one another. The second lowest or "No. 2", is the main seam, and furnishes most of the coal produced. It is up to 23 feet in thickness, but only in the lower part is the coal of good enough quality to be worth working. The portion mined ranges from four to 15 feet in thickness.

The coal produced contains from 12 to 16 per cent. of ash, and is a rather dull, hard, steam coal which stands handling and transportation extremely well.

The total available reserves of coal in the Witbank area were estimated in 1922 by Wybergh*, at 7,956,000,000 short tons, having an average evaporative power of 11·2.

Natal.—Natal also possesses three distinct coal fields of which the Klip River, or Main Line Field, is the most extensive. This stretches from Elandslaagte to Newcastle, and is 40 miles wide. There are two commercially valuable seams, known as the "Top" and "Bottom". They are usually from three to five feet thick, and from five to six feet apart, and are fairly persistent throughout the area. They yield high-grade steam coals, the best found in South Africa, which are in great demand for the bunker trade.

The total reserve of coal in the field is very large, but the reserves of high-grade coal are relatively small and will, it is believed, be exhausted within forty years at the present rate of output of about 2,300,000 tons per annum.

Reference must also be made to the Vryheid Coal Fields which at the present time are responsible for 55 per cent. of the total Natal output. There are four seams, ranging from $2\frac{1}{2}$ feet to $5\frac{1}{2}$ feet in thickness. The coal is, on the whole, of excellent quality, and the coke made at the Bernica Colliery is recognized as the best South African coke.

The Orange Free State.—In the northern part of this province there is a great coal field having an area of probably 10,000 square miles. The coal seams vary in

*Wybergh, W. J. The Coal Resources of the Union of South Africa. Memoir No. 19, Geol. Surv., Union of S. Africa, 1928, Vols. I, II and III.

number from one to four. Their aggregate thickness ranges from six to 63 feet. The total coal reserves of this Orange Free State field are probably considerably in excess of 100,000,000,000 tons.

Southern Rhodesia.—Coal is known to exist at widely separated points in the vast areas occupied by the Karroo System in this territory. Up to the present time mining operations have been confined to the Wankie Field which lies athwart the Bulawayo-Victoria Falls Railway, about 65 miles south-east of the Falls. The coal field is bounded on the north-west by the great Deka Fault. Within it there are two distinct basins of which the north-westerly is being worked.* The main seam ranges from six to 40 feet in thickness, the thickness increasing toward the west. The coal is of good quality and makes an excellent coke, which is very extensively employed in the great copper smelters of the Southern Belgian Congo.

The field is estimated to contain 6,000,000,000 tons of coal. It will be noted from the table that the output for 1928 exceeded 1,200,000 tons.

TABLE OF PROXIMATE ANALYSES OF SOUTH AFRICAN COAL

Field.	Colliery.	Moisture %	Volatile Matter %	Fixed Carbon %	Ash %	Sulphur %	Evaporative Value†.
Witbank (Transvaal)	Witbank	0·90	27·0	58·3	13·8	1·24	13·0
Klip River (Natal)	Natal Navigation	0·9	21·8	69·9	7·4	1·30	14·0 to 15·15
Vryheid (Natal)	Bernica	0·7	20·4	69·0	9·9	0·43	14·5
Wankie (Southern Rhodesia)	Wankie	0·7	23·7	65·8	9·8	n.d.	13·9

**Cf.* Lightfoot, B. The Wankie Coal Field, Bull. Geol. Surv., S. Rhodesia. In the press.

†Pounds of water per pound of coal, to convert into gramme-calories multiply by 537.

Statistics of Production.—The coal output of South Africa for 1928 was 14,610,771 tons valued at £4,209,430. The production of the individual territories and provinces was as follows :—

Territory.	Tons Sold.	Value at Pit's Mouth.	Value per ton.
UNION OF SOUTH AFRICA* ..	13,403,907	£3,697,611	5s. 6·2d.
Transvaal	7,669,374	1,903,905	4s. 11·58d.
Natal	4,641,365	1,493,679	6s. 5·24d.
Orange Free State ..	1,088,109	296,694	5s. 5·44d.
Cape	5,059	3,333	13s. 2·12d.
SOUTHERN RHODESIA ..	1,206,864	511,819	8s. 5·78d.
GRAND TOTAL	14,610,771	£4,209,430	5s. 9·15d.

Platinum.†—The last five years have seen the establishment in South Africa of a very promising platinum industry. The Union already ranks third among the world's producers of the metal. Before the end of 1930 she will rank second, and there is every prospect of her eventually being the leading producer as her primary deposits are incomparably the greatest.

These deposits are in the lower part of the Norite Zone of the Bushveld Igneous Complex in the Rustenburg, Potgietersrust and Lydenburg districts.

They are extremely varied. We need here only consider the principal types. They are :

(1) Dunite deposits.
(2) The deposits on the Merensky Horizon in which platinum occurs in association with magmatic nickel-copper-iron sulphides.

*The figures for the Union of South Africa are subject to final revision.

†*Cf.* Wagner, P. A. "The Platinum Mines of South Africa." (In the press.)

(3) Contact-metasomatic deposits in which platinum occurs in silicated dolomite flooring the Bushveld Complex ; and

(4) Pegmatitic deposits.

(1) *Dunite Deposits*.—Here two main subtypes may be distinguished, namely, (a) hortonolite-dunite deposits, and (b) deposits in which platinum occurs in association with iron-rich olivine approximating in composition to hyalosiderite.

(a) In these deposits platinum is found in steeply inclined pipe or parsnip-shaped segregations, and smaller lenses and veins of hortonolite-dunite in olivine-dunite. The bulk of the platinum is present in the metallic state in well-formed crystals, nuggets and irregular grains. Below water level the metallic platinum is accompanied by sperrylite and platinum sulph-arsenide.

Only two workable occurrences have so far been discovered. They are the Onverwacht and Mooihoek mines, situated in the western part of the Lydenburg district of the Transvaal. In the former the ore-body, which was roughly circular at the outcrop, and measured 60 by 60 feet, has been opened up to a depth of 800 feet where it is much smaller. The platinum content of the hortonolite-dunite ranges from nil to 1,213 dwts. per ton, the average grade of the ore at present worked being about 4·5 dwts.

The Mooihoek Mine has been worked to a depth of 400 feet.

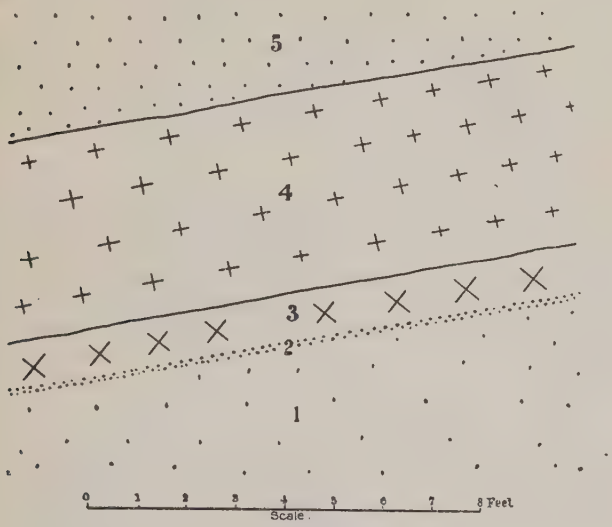
(b) The outstanding occurrence of this type is the Driekop Mine, situated three miles north-north-east of the Mooihoek Mine. Platinum occurs here in relatively small segregations, and veins of iron-rich olivine-dunite in

olivine-dunite. The platinum is partly in the metallic state, and partly in the form of sperrylite and platinum sulph-arsenide. The mine has been successfully opened up to a depth of 460 feet. It is bigger than the Mooihoek or Onverwacht pipes, but of lower grade.

(2) *Deposits on the Merensky Horizon.*—These are among the greatest concentrations of mineral wealth on the face of the earth. They take the form of remarkably persistent, gently inclined sheets or layers of dark-coloured platinum-bearing rock, or rocks intercalated with light-coloured norite and anorthosite. Where first discovered by Dr. H. Merensky on the farm Maandagshoek No. 148, in the Lydenburg district, the platinum horizon consists entirely of dark-coloured pyroxenitic pseudo-porphyritic diallage-norite. In the Rustenburg district, on the other hand, where it attains its most important development, the horizon is composite in character, being made up of distinct layers of pseudo-porphyritic diallage-norite, felspathic harzburgite and a thin seam of chromitite known as the "Chrome Band." The platinum values are concentrated mainly in the Chrome Band, and in the coarse felspathic harzburgite over or underlying it. The platinum content of the workable portion of the horizon ranges up to several ounces to the ton. In the Rustenburg district it has been proved over considerable distances to average six dwts. of platinum per ton over a stoping width, and from 10 to 12 dwts. over the 12-inch sector which it is proposed to mill.

The platinum, as already stated, is associated with magmatic nickel-copper-iron sulphides. It is present in the primary ore mainly as a platinum sulph-arsenide, for which the writer has proposed the name cooperite, in honour of its discoverer, R. A. Cooper, and partly as sperrylite. Above water level, portion of the platinum is in the native state.

SECTION ACROSS MERENSKY PLATINUM HORIZON as intersected at a depth of 270 feet in the West Vertical Shaft on Kroondal No. 177 south-east of Rustenburg.



1. Spotted Anorthositic Norite.
2. Chrome Band.
3. Coarse Felspathic Harzburgite.
4. Pseudo-porphyritic Diallage Norite ("Merensky Reef").
5. Spotted Hanging Wall Norite.

The Chrome Band (2) and overlying Felspathic Harzburgite (3) carry an average of 13.6 dwt. of Platinum metals per ton over an average thickness of 13 inches.

The overlying Merensky Reef (4) carries an average of 1.5 dwt. of Platinum metals per ton.

(3) *Contact-Metasomatic Deposits*.—These are situated to the north-north-west of Potgietersrust. The Merensky Horizon is here in places present in its normal development. In other places it is represented by great irregular lenses resting directly on silicated dolomite which has been impregnated with platinum, and thus constitutes an important part of the ore-bodies. In these contact-metasomatic deposits platinum is present as sperrylite and palladium as an antimonide, discovered by H. R. Adam, for which the writer has proposed the name stibiopalladinite.

(4) *Pegmatitic Deposits*.—On the farm Tweefontein, No. 1033, situated 15 miles north-north-west of Rustenburg, platinum in the form of sperrylite, and palladium in the form of stibiopalladinite are found in lenses and "eyes" of pegmatite in the banded iron-stones of the Pretoria Series here flooring the Bushveld Complex. The deposits are of great interest, but have no economic significance

Statistics and Prospects of the Industry.—Sales of platinum from the Transvaal mines amounted in 1928 to 17,828 ounces valued at £241,110. This platinum was derived entirely from the dunite deposits of the Lydenburg district. There was also a fairly considerable production from the Potgietersrust district, but this was not sold. A plant, with a capacity of 28,000 ounces per annum, is being erected at the Kroondal-Klipfontein Mine near Rustenburg; another, with a capacity of 10,000 tons of ore per month, on the farm Waterval, adjoining Kroondal, and yet another, with a capacity of 250 tons of ore per diem, on the farm Swartklip, 60 miles north-north-east of Rustenburg. All three plants should be producing by the middle of 1930, when a great increase in the platinum output of the Union may be anticipated.

Silver.—The only silver at present being recovered in South Africa is that contained in the gold bullion

produced by the Witwatersrand and other gold mines. The output, including that of Southern Rhodesia, amounted in 1928 to 1,135,178 ounces valued at £135,236.

Copper.—Copper mining has been carried out without interruption in South Africa since 1852, the total value of the output to date being roughly £28,000,000. Practically the whole of the production has come from the deposits of Little Namaqualand, the Messina Copper Belt, situated in the Zoutpansberg district of the Transvaal, and the Falcon Mine situated at Umvuma in Southern Rhodesia.

The Namaqualand Occurrences are among the best authenticated examples of copper deposits formed by direct magmatic segregation.* They take the form of irregular dykes and intrusions of a genetically connected series of rocks, ranging from anorthosite through mica-diorite and norite to hypersthenite, which contain, as primary constituents, varying amounts of chalcopyrite which may or may not be accompanied by bornite and pyrrhotite. The deposits are for the most part worked out, the West and East Homeeb Mines, east of Concordia, being at the present time the sole sources of production. A large reserve of low-grade ore has, however, been opened up at the Nababeep Mine, and there is a possibility of the celebrated O'Kiep Mine being re-opened.

The Messina Copper Belt.—This extends for a distance of 20 miles in a general east-north-east to west-south-west direction from the farm Oostenryk No. 1421, to the Limpopo River in the extreme northern part of the Zoutpansberg district of the Transvaal. It is honeycombed with ancient copper workings, and was evidently the scene for hundreds, and perhaps thousands, of years before the advent of the white man, of native copper mining operations.

**Cf.* Rogers, A. W. Proc. Geol. Soc., S. Africa, 1916, pp. xxi-xxxiv.

The most important copper deposits so far discovered on it are those exploited by the Messina Mine, situated on the farm Berkenrode No. 1425, five miles south of the Limpopo. The ore-bodies are of the nature of irregular, discontinuous, quartz lodes and ellipsoidal, quartz bodies following well-defined zones of fracture within the main crush zones. The ore minerals are bornite, chalcopyrite and chalcocite. Both supergene and primary chalcocite are present. The deposits have been opened up to a depth of 2,300 feet. Recent developments at depth have been excellent, and the mine has, without doubt, a long life before it.

The Falcon Mine, Southern Rhodesia, which produced considerable amounts of copper between 1913 and 1920, was closed down in the latter year, and there does not appear to be much prospect of its being re-opened.

The copper production of the Union of South Africa for 1928 was 9,820 tons valued at £603,243. The Messina Mine was responsible for approximately three-quarters of the output.

Tin.—The most productive tin deposits so far discovered in South Africa are situated in the Transvaal. They occur in the red granite and granophyre constituting the upper part of the Bushveld Igneous Complex, and in the felsites and sedimentary rocks of the Rooiberg series by which it is roofed.

The most important sources of production at the present time are the remarkable pipes in red granite, worked at the Zaaiplaats Mine north-west of Potgietersrust, impregnations in miarolitic granite at the same locality, irregular replacements in red granite, worked at the Mutue Fides Mine, situated 70 miles south-south-east of Zaaiplaats, and the lode deposits of Rooiberg, Nieuwpoort and Leeuwpoort, situated in the south-western part of the Waterberg district.

Plate 20.] THE ONVERWACHT PLATINUM MINE, LYDENBURG DISTRICT, TRANSVAAL.

During 1928 these deposits produced concentrates estimated to contain 1,344 tons of metallic tin valued at £268,618.

Iron Ore.*—It has been established during the past 15 years that South Africa has fairly large reserves of high-grade, and vast reserves of medium-grade, iron ores, apart from the titaniferous ores of the Bushveld Igneous Complex which are the greatest of their kind.

The most important deposits are (1) the sedimentary ores of the Pretoria Series in the Transvaal, (2) the sedimentary ores of the Karroo System in Natal, and (3) replacement deposits and secondary concentrations of high-grade hematite of the Lake Superior type, occurring in the Crocodile River Ward of the Rustenburg district of the Transvaal, and near Postmasburg in Griqualand West.

(1) The principal deposit in the Pretoria Series is the so-called magnetic quartzite, an extraordinary persistent bed of arenaceous magnetite-hematite-chamosite-oolite, ranging in thickness from four feet to 20 feet, which can be traced for hundreds of miles.

(2) The most important occurrence so far opened up in the Karroo beds in Natal is a bed of black-band or sideritic ironstone on the farm Prestwick, near Dundee.

(3) The hematites occurring in the Crocodile River and Postmasburg districts are of great purity, averaging from 60 to 69 per cent. of metallic iron.

The ores of the Crocodile River deposits and of the Pretoria Series will form the basis of the national iron industry to be established at Pretoria. The black-band iron ore mined at Prestwick forms the basis of the industry at Newcastle in Natal.

**Cf.* Wagner, P. A. Memoir No. 26, Geol. Surv., Union of S. Africa.

Salt.—The Union of South Africa is happy in the possession of practically permanent supplies of common salt. These are contained in the salt pans which are such characteristic features of certain parts of the country. The salt is derived from the pans themselves or from brine found below their floors. The most important pans are situated in Griqualand West and the South-western Transvaal on Dwyka tillite or Dwyka shale; the salt, which is evidently leached out of these rocks to which it is indigenous, is continually replenished by a process of natural concentration. The salt, almost without exception, contains notable amounts of sodium sulphate. The annual output of salt is roughly 80,000 tons valued at about £115,000.

Manganese.—Manganese ores have a wide distribution in the Union of South Africa, but the only really important deposits discovered so far are situated north of Postmasburg in Griqualand West*. They take the form of great sheets and irregular bodies, up to 20 feet in thickness, of psilomelane formed by the replacement of beds of shale belonging to the basal portion of the Matsap System. Huge reserves are available, and arrangements are being made to work the deposits on a large scale.

"White" Arsenic.—"White" Arsenic (arsenious oxide) is recovered as a by-product of gold-winning in the Barberton gold district of the Transvaal, and at the Cam and Motor Mine, Southern Rhodesia. At the latter there is also a small production of antimony.

Pyrite.—The pyritic concentrates of certain gold mines in the Sabie and Pilgrims Rest district of the Transvaal constitute at the present time the chief South

*Cf. Hall, A. L. Trans. Geol. Soc. of S. Africa, 1926, pp. 17 and 46, and Nel, L. T. Geological Survey Memoir (unpublished) on the Postmasburg Deposits.

African source of sulphur for the manufacture of sulphuric acid. Production amounted in 1928 to 4,138 tons valued at £6,087.

Nickel.—South Africa has large and varied resources of nickel ores. Hitherto there has been no output of the metal, but it promises to be a valuable by-product of the platinum industry. The sulphidic ores of the Merensky Horizon contain an average of 0·2 per cent. of nickel, and tests have proved that 90 per cent. of this can be recovered by flotation. As these ores are to be worked on a large scale, there can be no question that considerable amounts of nickel will be recovered.

Other potential sources of supply are : the magmatic deposits on Vlakfontein No. 902, situated west of the Pilansberg in the Rustenburg district of the Transvaal ; the magmatic nickel-copper deposits of Insizwa and Tabankulu in Griqualand East ; an occurrence on the property of the Scotia Talc Company in the Barberton district of the Transvaal, where nickel occurs in the form of trevorite, $(Fe,Ni)_3O_4$; and a newly discovered deposit on the Kafuzi River in Southern Rhodesia, in which nickel occurs as niccolite and chloanthite in serpentine.

Tungsten Ores.—Tungsten ores occur at various localities in the Bushveld Complex and in Southern Rhodesia. At the present time the only production is from the Hartley district in Southern Rhodesia, where scheelite is recovered as a by-product of gold mining.

Lead.—Deposits of lead have been discovered and worked at a number of localities in the Transvaal and Southern Rhodesia. At the present time the output of the metal, which during the period 1923-1925 attained considerable proportions, is negligible owing to the exhaustion of the more productive occurrences. The production of the Union for 1928, amounting to 42 tons

valued at £571, was derived from small replacement deposits in the dolomite of the Marico district of the Transvaal.

Uranium and Radium,—In 1927 there was discovered in the valley of the Back River in Gordonia, about six miles north of its confluence with the Orange, a series of veins and lenses of coarse pegmatite carrying, in addition to galena, gadolinite and allanite, crystals and nodular masses of strongly radio-active uraninite up to several inches across. A good deal of exploratory work has been done on the deposits. This has proved them to be very patchy as to uraninite content. There is thus, unfortunately, no prospect of an appreciable production of radium from this source.

Fluorspar.—Fluorspar is mined in the Marico district of the Transvaal, and also to the west of Warmbaths in the Transvaal. In the former area the mineral occurs in pipe-shaped and irregular replacement deposits in the dolomite series of the Transvaal System. In the latter it is found in, or in association with, great flat-dipping sheets of pegmatite in the red granite of the Bushveld Igneous Complex.

Graphite.—There is a small production of graphite in the Transvaal from a deposit situated on the farm Goedehoop No. 223, in the Zoutpansberg district of the Transvaal. Production during 1928 amounted to 56 tons valued at £1,670.

Mica.—Mica of excellent quality is mined in the Lomagundi district of Southern Rhodesia and in the Leydsdorp district of the Transvaal. The Southern Rhodesian production for 1928 was valued at £23,920, and that of the Transvaal at £8,422.

Barytes.—There are important deposits of this mineral in the Gwelo district of Southern Rhodesia and near Riversdale in the Cape Province.

Magnesite.—Magnesite of the "dense" variety is mined near Magnesite Siding on the Pretoria-Lourenço Marques Railway. Production during 1928 amounted to 1,555 tons valued at £3,161.

Talc.—There are extensive deposits of both massive and foliated talc in the ancient serpentines and basic schists of the Jamestown Series of the Swaziland System. An important occurrence is being worked on the farm Strathmore near Malelane in the Eastern Transvaal. The production during 1928 amounted to 596 tons valued at £3,993.

Soda.—An average of about 2,400 tons per annum of pure calcined sodium carbonate is produced at the Pretoria Salt Pan by the South African Alkali, Limited, the soda being obtained by fractional crystallization from the brine pumped from the floor of the pan. The production for 1928 amounted to 2,662 tons valued at £30,127.

Gypsum.—Gypsum is quarried in fairly considerable quantities in Griqualand West and the adjacent north-western portion of the Orange Free State. Here the mineral occurs in many localities, in seams and beds of loose crystals or in irregular masses, in superficial deposits of clay, silt and sand occupying pans and old marshes, the gypsum evidently having been deposited from surface waters.

Mineral Paints.—Pure yellow and red ochre are quarried at Dick's farm, 20 miles east of Newcastle, in Natal, the material worked being an ochreous phase of a bed of iron ore occurring in the Coal Measure series of the Karroo System. Ochres and mineral paints are also worked at other localities in Natal, and brown umber occurs in the dolomite north of Krugersdorp in the Transvaal.

Building and Ornamental Stones.—South Africa is rich in all kinds of building materials including ornamental stones and marble. A large deposit of white and fancy marbles occurs on the farms Marble Hall No. 248, and Scherp Arabie No. 367, situated in the Bushveld about 100 miles north-east of Pretoria. It is at present being tested by systematic boring. There are also marble deposits on the farm Buffelspoort No. 370, situated 30 miles north of Brits in the Transvaal, and on the Holle River in the Vanrynsdorp district of the Cape Province.

Clays.—Both ordinary clays, suitable for brick and tile making, and fire-clays, suitable for refractories, have a wide distribution in the Union and Southern Rhodesia.

Limestone and Dolomite.—The Union and Southern Rhodesia are on the whole rather poorly off in limestone suitable for industrial purposes, but have vast reserves of dolomite. Limestones of various kinds are none the less being quarried on a large scale in many localities. They are used largely for the production of Portland cement.

Oil Shale.—True torbanite, consisting largely of minute "kerogen" bodies, is developed on several horizons in the Coal Measure series of the Karroo System in the Bethal, Ermelo, Wakkerstroom and Greylingstad districts of the Transvaal, and in the Utrecht and Dundee districts of Natal. The deposits are, unfortunately, thin compared with beds of oil shale found in other parts of the world, and in some localities patchy as to distribution, but they are in part fairly rich, yielding up to 100 gallons of oil per ton. A good deal of exploratory work has been done on the deposits, but no attempt has so far been made to work them.

Phosphates.—There are extensive deposits of rock phosphates at Saldanha Bay on the west coast of the Cape Province, formed by phosphatization of granite and quartz porphyry detritus and to a less extent by the

phosphatization of these rocks themselves. They are, unfortunately, too poor in phosphoric oxide to be worth working. A deposit of phosphatized beach or dune sand occurs on Cravens Gift and the adjoining farms near Mamre Road Station, north of Cape Town.

A series of pegmatite veins carrying chlorapatite in the form of large isolated crystals and in irregular pockets and steeply dipping beds and stringers, is being opened up on Spelonken Water No. 927, and adjoining farms in the Zoutpansberg district.

Kieselguhr.—Kieselguhr or diatomite has a wide distribution in the Ermelo district of the Transvaal and in Griqualand West and Gordonia. It occurs as a black peaty deposit occupying the beds of small fresh-water marshes or in shallow pans in association with calcareous tufa.

Glass and Other Sands.—Sands suitable for the making of all ordinary grades of glassware occur at Philippi on the Cape Flats near Cape Town, and also at Zandfontein, Silverton, Pienaarspoort and other localities near Pretoria. Sands suitable for building purposes, and for concrete, have a wide distribution. Good moulding sand is quarried at Vereeniging, near Somerset West and Pretoria.

Natural Gas.—Natural gas has, so far, only been struck in considerable quantity on the farm Gruisfontein in the Heidelberg district, Transvaal, where it is encountered at a depth of 540 feet below a sill of dolerite in the Karroo beds that has acted as an impervious cover.

Large volumes of carbon dioxide issue along a fault of Dwyka tillite on the farm Hughenden, Lot 10 and Lot 7, in Alfred County, Natal, The gas is collected and used for aerating mineral waters. Sales during 1928 realized £850.

Amethyst.—There is a small production of amethyst from a quartz-amethyst vein in the Old Granite north of Johannesburg.

Emeralds.—The latest addition to the already very long list of the mineral products of South Africa are emeralds.

They are found in the Leydsdorp district in the north-eastern Transvaal, where there is being opened up what promises to be an extensive emerald-beryl field. The original discovery was made late in 1927 on Somerset Hill, situated 10 miles east-north-east of Leydsdorp, and 14½ miles from Gravelott Siding. Emerald and beryl are found here in biotite schist near the contact of that rock with a great belt of pegmatite*, and also in pegmatite veins cutting mica schist. Many of the emeralds are of a very fine deep colour, and some of them are of excellent quality. The majority, however, are badly cracked and flawed. Cut, flawless stones have realized as much as £100 per carat.

Apart from this occurrence, which is now known as the Somerset Mine, a number of others have been found in the same area, and several companies are at present operating in the field.

Sales of emeralds from the Somerset Mine during 1928 realised £3,195.

**Cf.* Le Grange, J. M. "A Study of the Occurrence of Beryls in the North-eastern Transvaal with some Observations on Metallogenetic Zoning in the Murchison Range." Thesis presented in 1929 to the Faculty of Science, University of the Witwatersrand, for the Degree of Master of Science.

Plate 21.1 THE PRETORIA SALT PAN. SITUATED 25 MILES NORTH-WEST OF PRETORIA.

IX.

SOUTH AFRICAN AGRICULTURE.

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History.—European agriculture had its birth in South Africa with the arrival of Jan van Riebeeck at Table Bay in 1652. The settlers took steps to supply their own needs and those of passing ships for fresh vegetables and meat. In 1657, permission was granted to eleven settlers to conduct farming on their own account in the vicinity of Cape Town. At the beginning of the eighteenth century, the farming settlements had extended about fifty or more miles inland to what is at present known as Tulbagh. The French Huguenots of 1688 had introduced grape-growing into the country. A start was soon made also with wheat growing and cattle farming at the Cape to supply the requirements of the settlers. During the eighteenth century, settlers moved further and further inland, and at the beginning of the nineteenth century the settlement had extended to about 400 miles inland to the eastward. As transportation and marketing facilities were limited, farming activities were carried on to supply the needs of individual farmers of the settlement at Cape Town, and of passing ships. During the second quarter of the nineteenth century, a number of Dutch families moved into Natal, the Free State and the Transvaal. The discovery of diamonds at Kimberley in 1867 and gold on the Witwatersrand in 1886, and the extension of railway facilities, opened up new internal and external marketing opportunities. In the more settled parts inland a gradual process of intensification from pastoral to grain, fruit and vegetable farming occurred. Especially since the Anglo-

Boer War of 1899 to 1902 great attention has been given to the application of scientific methods to agriculture, and vast strides have been made in agricultural development.

Agriculture of the Union.—Agriculture is the most important industry of South Africa. Forty-two per cent. of the European population are rural. In 1921, about 166,000 adult Europeans (15 years of age and over), including European wage-earners, were engaged in farming.

Of the total area of 143,000,000 morgen* or 300,000,000 acres of land in the Union, 97,000,000 morgen or 205,000,000 acres, or approximately 68 per cent., were occupied as farm land in 1926. Of the total area of occupied farms, 5,000,000 morgen or 5 per cent. were under cultivation.

It is estimated that about 3,000,000 acres or one per cent. of the total area of the Union is irrigable. A number of individual and State irrigation schemes exist, including the Hartebeestpoort dam, Lake Mentz, and Tarka.

According to the 1927 census, there were 93,000 occupied farms in the Union. Fifty-one per cent. of the number of occupied farms and agricultural holdings are less than 500 morgen in extent, but comprise less than 10 per cent. of the total farm area. Sixty-three per cent. of the total farm area in the Cape Province is composed of farms of more than 5,000 morgen. Holdings of from 101 to 500 morgen are in the majority in all the four provinces, which indicates that farming is becoming more intensified. In the Stellenbosch district, 60 per cent. of the farms are less than 100 morgen in extent, in the Potchefstroom district (Transvaal) more than 33 per cent. Small holdings predominate where the climatic conditions are somewhat better than the mean.

*1 morgen=2·11654 acres.

The total agricultural valuation of land and improvements, machinery and implements and live-stock is more than £500,000,000, viz.:

Agricultural land and improvements	£378,000,000
Estimated total value of agricultural machinery and implements ..	£15,000,000
Estimated value of livestock, 1926	£116,000,000
	£509,000,000

This estimate gives a value for agricultural land and improvements of £4,066 per average farm (1,049 morgen) for the Union, and an average value per morgen of £3. 18s. 6d.

An estimate of the value of agricultural production during the 1925-26 crop-year is £70,000,000 on a basis of market values, or £57,000,000 at average farm values, while that from mines (1926) amounts to £59,000,000, and from industries (1925/26) to £92,000,000, of which about £30,000,000 represents farm products manufactured for consumption. A large proportion of the £92,000,000 value of industries represents the production of other industries and cannot fairly be used as a basis for comparison with agriculture and mining. In the case of the figure for industries, the value of materials used amounted to £47,000,000, and the value added to the materials £45,000,000.

Soil Regions and Farming Types.—Topography, climate, soil and economic conditions are amongst the main factors which have influenced the development of the main types of farming in various sections of the country. The sub-tropical and temperate character of the climate makes it possible to produce any agricultural product in almost any part of the country, but owing to the above-named factors, the production on a large scale

of the chief agricultural products are fairly definitely limited to various sections of the country.

The Division of Chemistry of the Department of Agriculture divides the soils of the Union roughly into nine main areas, called soil regions. The chief factors that characterize a soil region are climate, geology and topography. The Division states that in a very brief description, it is impossible to give more than an outline of each soil region and farming type; many exceptions to the general rule cannot even be mentioned. Broadly speaking, the soils are very deficient in phosphates, especially in the areas of highest rainfall. In the driest regions, soils of alluvial origin are often strongly alkaline.

1. *The South-western and Southern portions of the Cape Province.*—This is a winter rainfall area. The soils are for the most part light brown and sandy. There are also considerable areas of brown, grey and yellowish-brown heavy loams. Many of the soils have been subjected to heavy leaching and are very poor. Gravel and lateritic ironstone are of common occurrence. Winter cereals, tobacco, citrus, deciduous fruit, grapes, sweet potatoes and pineapples (eastern limit) are grown extensively. A good deal of lucerne and some fruit are grown under irrigation in the drier parts.

2. *The Eastern Districts of the Cape Province.*—The soils are brown to reddish-brown loams and greyish sandy loams, often of fair depth. Gravel and clay subsoils are common. Maize, wheat, other cereals and fruit, including citrus, are grown. It is a good sheep and cattle area. Dairying is carried on in parts.

3. *The Karroo country.*—The soils are reddish-brown to greyish-brown sandy loams. They are shallow and overlie shale or calcareous tufa. The veld is very suitable for merino and Persian sheep. Parts are very suitable for Angora goats. There are some very valuable

Plate 22.] A SOUTH AFRICAN SHEEP FARM.

irrigated areas on which lucerne, fruit and winter cereals are produced.

4. *The aeolian sands of the Western Grass Veld and a part of the Northern Karroo.*— Dryland farming is usually not possible here; it is mainly stock country. Lucerne, cotton, grapes and citrus are grown under irrigation, and a good deal of wheat is grown in zaaidams (temporary earth dams).

5. *The Natal Coastal Belt.*—The soils of low lying areas are dark red and brown loams. Sandy soils are common on the hillsides and high lying situations. Sugar, tea, maize, cotton, ground-nuts, sub-tropical and tropical fruits are grown.

6. *The area from Swaziland through the Natal Midlands to Umtata.*—The principal soils are the red loams. Sandy soils are common in parts. Maize, winter cereals and acacias are the principal crops. Cattle and sheep do well in some localities, and a good deal of dairying is carried on.

7. *The Eastern Free State and the portion of Natal adjacent to Basutoland, and stretching towards Vryheid.* —The soils are usually brownish, sandy loams underlain by heavy sub-soils. Maize, potatoes and winter cereals, cattle and sheep do well in this area.

8. *The High Veld, namely, the part of the Transvaal lying south of a line drawn through Mafeking and Lourenço Marques, the central, southern and western portions of the Free State.*—The grazing is suitable for big and small stock. The soils are usually light loams underlain by heavy sub-soils and sometimes hardpans. The moister areas are very suitable for maize and potatoes, the drier portions of the Free State for stock only. Winter cereals and deciduous fruits are grown.

9. *The portion of the Transvaal that lies to the north of a line drawn through Mafeking and Lourenço*

Marques.—The soils are dark, reddish to black, sandy loams, often of considerable depth and suitable for cotton, tobacco, ground-nuts, millet, citrus, tropical and sub-tropical fruits and vegetables. Big and small stock are kept.

All the soil regions, except the first-mentioned, are in the summer rainfall area.

On almost every farm a certain number of poultry and fruit trees may be found, although farming in these directions may not be on a commercial scale. Around the urban centres vegetable growing and truck farming are carried out on an extensive scale.

Maize.—2,500,000 morgen were under maize in 1926-27, and over 18,000,000 bags of maize were produced. Most of the maize is grown in the so-called maize belt or maize triangle, an area comprising the North-Eastern Free State, the Natal Highveld and the Transvaal Highveld. The average production is 4 bags (200lb. each) per acre as compared with 16 bags in the United States and 20 bags in the Argentine. Better cultivation and efficient fertilization have given yields of 10 bags and higher. In 1928 nearly 6,000,000 bags of maize, valued at £3,500,000, and maize meal valued at £430,000, were exported. Maize production has made excellent progress since Union, the production having increased from 8,600,000 bags in 1911 to 24,300,000 bags in 1924-25.

Wheat.—400,000 morgen were under wheat in 1926-27. Of this area, almost 70 per cent. was in the Cape Province, about 20 per cent. in the Free State, and about 9 per cent. in the Transvaal. The production in 1927 was slightly over 2,000,000 bags of 200lb. weight. The districts of Bredasdorp, Caledon, Malmesbury, Piquetberg and Porterville in the Western Province, Ladybrand in the Free State and Lydenburg in the Transvaal, are the main wheat producing districts. The

Union grows only about one-third of the wheat required for local consumption. Large quantities of wheat and flour are imported into the country; on wheat there is an import duty of 3s. 2d. per 200lb., and that on flour is 7s. 4d. per 200lb. The production of wheat per morgen is 5·8 bags compared with 11·5 bags in Canada and 15·3 bags in Germany.

Oats.—274,000 morgen were under oats in 1926-27, of which 66 per cent. was in the Cape Province, about 20 per cent. in the Free State and 8 per cent. in the Transvaal. The average production of oats, besides the oats harvested and used on the farm in unthrashed condition, for the four years 1923-26, was slightly over 1,000,000 bags of 200lb. each. The bulk of the crop is produced in the South-Western districts of the Cape.

Barley.—There were only 32,500 morgen under barley in 1927, and of this over 90 per cent. was in the Cape Province. The main production area is the South-Western Cape. The average production for the four years 1923-26 was 264,000 bags of 200lb. each.

Fodder Crops.—Various fodder crops are cultivated in the Union. Lucerne is found on the majority of farms, but farmers specialize in its production for marketing purposes in such areas as the Sundays River Valley, the settlements near Uppington, around Johannesburg and under various irrigation schemes.

Teff grows well on the Highveld of the Transvaal, Free State and Natal and the Eastern province of the Cape. In 1925-26 the following quantites of fodder crops were produced in the Union:—

	Area Morgen	Hay in lb.	Lb.
Lucerne ..	89,000	313,000,000	—
Teff	112,000	217,000,000	—
Manna ..	18,000	24,000,000	—
Silage ..	—	—	198,000,000

Fruit.—The Fruit Industry, deciduous as well as citrus, has made great progress in recent years. The Western Province (Cape), the Eastern Free State and limited areas north of Johannesburg and Pretoria are the main commercial deciduous fruit areas. Citrus fruits for commercial purposes are mainly produced in Clanwilliam, Sundays River Valley, Kat River, Marico, Rustenburg, Zebediela, Tzaneen and Muden (Natal). Dried fruit is mainly exported from the Western Province (Cape). In 1926 there were 4,300,000 citrus trees; 1,300,000 cases of citrus fruit were railed for sale locally, and 600,000 cases were exported. The value of citrus fruit exported in 1926 was £340,000; 839,000 cases, valued at £421,000, were exported in 1927. The number of deciduous trees grown for export of the fruit in 1925 was 2,600,000, and the value of the exports was £268,000. In 1925, there were 2,900,000 vines grown for the purpose of producing grapes for export on approximately 28,000 morgen, mainly in the South-Western districts of the Cape, and the number of cases exported was 331,000, valued at £94,000. In 1927, the value of grapes exported amounted to £170,000, and the value of dried fruit exported was £164,000. The Fruit Industry has great potentialities, and in the near future the exports to European countries will undoubtedly increase greatly. South Africa is fortunate in that its fruit seasons are at different times from those in the Northern Hemisphere. In addition to citrus and deciduous fruits, a variety of other fruits of less commercial value are produced, such as melons, mangoes, grape-fruit, figs, pine-apples, bananas and papaws.

Sugar.—In 1926-27 there were 245,000 acres under sugar cane in the eastern coastal section of Natal; 243,000 short tons (2,000lb.) of sugar were produced, of which 67,000 tons, valued at £890,000, were exported. In 1927-28, the export amounted to 69,000 tons, valued

at £963,000. About a year ago the planters and millers came to an agreement, and obtained State support, whereby sugar prices would be stabilized, planters and millers would be assured of definite prices, and the consuming public could not be charged more than certain limiting prices for sugar. This arrangement has been a means of placing the sugar industry on a more stable and assured basis.

Tobacco.—The production of tobacco has shown enormous expansion during the last few years, increasing from 11,400,000lb. in 1924 to an estimated quantity of 24,000,000lb. in 1928. The Union's estimated requirement is only 13,000,000lb. per annum. Special steps have been taken to enlarge the overseas market for the surplus over local requirements by sending a senior officer of the Department of Agriculture overseas. All tobacco is sold through the medium of a co-operative society. The principal producing areas are the Magaliesberg areas in the Transvaal, the Vaal River area (Vredefort and Potchefstroom), the Piet Retief and Barberton areas, the Kat River and Oudtshoorn areas, and the Turkish tobacco area of the Western Province. The production of tobacco can be greatly increased if sufficient profitable markets overseas can be found.

Cotton.—Strenuous efforts have been made during the past twenty years to develop cotton, especially in the northern Transvaal and eastern Natal, but owing to droughty conditions, great setbacks have been experienced. The production has increased from 14,000lb. in 1910-11 to over 8,000,000lb. in 1925-26.

Minor Crops.—The following approximate area and production of various other crops in 1925-26 indicate their relative importance: millet, 52,000 morgen, 753,000 bags; potatoes, 36,000 morgen, 1,000,000 bags; rye, 140,000 morgen, 267,000 bags; beans, 35,000 morgen,

163,000 bags ; ground-nuts, 14,000 morgen, 67,000 bags ; wine, 28,000 morgen, 13,200,000 gallons ; brandy, 38,000 gallons ; vinegar, 47,000 gallons ; 931,000 pigs, 6,400,000lb. bacon and ham.

Sheep.—South Africa's most important agricultural industry is, undoubtedly, sheep. With 36,000,000 sheep, South Africa takes fifth place amongst the countries of the world. Australia, Russia in Europe, the United States and the Argentine have greater numbers. Of the total world production of 2,900,000,000lb. of wool in 1925, British South Africa produced 185,000,000lb., or almost 7 per cent. In 1927-28, the wool export (grease equivalent) was 273,000,000lb., having a value of £18,500,000. In 1927-28, £1,900,000 worth of sheepskins was exported. In almost any area of the Union, there are farms where sheep would do well. At the present time the Karroo region and the Transkei, the south-western Free State and the Highveld of the Transvaal are the main sheep areas. In the Transkei, one morgen will support three sheep, in Prince Albert (Cape) four and more morgen are required for one sheep. During seasons of drought, large numbers of sheep are lost. The Merino is the main type of sheep. South African wool stands in the foremost rank in the world market.

Goats and Mohair.—South Africa produces more than half of the world's consumption of mohair. The value of mohair exports increased from £10 in 1857 to £1,650,000 in 1919. Owing to adverse conditions in South Africa on account of drought, the decreasing demand overseas and the development of sheep farming, the number of Angora goats has decreased considerably during the last few years. Angora goats decreased from 4,300,000 in 1911 to 1,400,000 in 1927, and the export value of mohair from £1,140,000 in 1924 to £807,000 in 1927. In addition to Angora goats, there were over 6,000,000 goats other than

Angora in 1927. The ordinary goat does well in the more arid sections of the Karroo and the north-western Cape.

Cattle.—Cattle play a very important part in farming in South Africa. They furnish practically all the beef and veal consumed in the country, supply practically all the butter and most of the cheese, and the trek ox is largely used for ploughing and hauling purposes. Cattle are raised throughout the Union. The northern Transvaal is a great ranching area, and the maize belt is bound to play a more important part in the future as a fattening area. In 1927 there were 10,400,000 cattle (including calves) in the Union, of which about 4,000,000 were native cattle of very low grade. A great deal remains to be done in grading up the cattle of the country if a profitable export trade in beef is to be developed. Over 500,000 head of cattle are slaughtered annually at the principal abattoirs in the Union. The total value of cattle slaughtered annually amounts to at least £3,000,000. The export trade in beef is still in a very unsatisfactory condition, although Italy has taken fairly large quantities of South African beef during the past few years.

Dairying.—A considerable area of the Union is well adapted to dairying, and much attention is being given to improving dairy cattle. In 1926 there were over 2,000,000 cows and heifers (two years old and over), exclusive of the native-owned stock, in the Union. All the principal dairy breeds are found throughout the Union, but, apart from the Africander cattle, Frieslands and Ayrshires predominate. Strenuous efforts are being made to improve the dairy stock through a scheme of milk-recording. The production of butter has increased from 11,300,000lb. in 1910-11 to 24,400,000lb. in 1926, and South Africa now produces sufficient butter for its local requirements. The various creamery organizations,

in conjunction with the Department of Agriculture, have recently formed a Central Board to stabilize, as far as possible, butter prices in the interests of the various parties concerned. In 1926-27 over 6,000,000lb. of cheese were produced. In December, 1926, there were in the Union 72 creameries with 51 auxiliary cream depots, 150 cheese factories, 2 margarine factories, 20 butter substitute factories and 1 condensed milk factory. The fact that New Zealand, with less than twice as many cows in milk as South Africa, produces almost nine times as much dairy products, indicates that there is great scope for improvement in dairying in South Africa.

Poultry.—The poultry industry has made great strides in the export of eggs since the Great War. In 1911, there were exported 2,700 cases of eggs (of 30 dozen each), in 1928 the export was increased to 115,700 cases. In the large urban centres co-operative egg circles have been formed, and while 2·9 per cent. of the total export in 1922 was done through co-operative egg circles, in 1928 the percentage was almost 40. The co-operative egg circles have given a great impetus to ensuring a better standardized product for the overseas market. The number of fowls in the Union was 10,800,000 (1926). The industry is still in an infant stage. It is capable of great expansion and improvement in every district of the Union. Strenuous efforts are being made to stimulate its development, and there is every prospect that it will experience great expansion during the coming years.

Ostrich Farming.—In 1913, the Union exported over 1,000,000lb. of ostrich feathers, valued at £2,900,000. Owing to over-production, the Great War, changing fashions and other causes, a set-back in prices and demand has occurred, and at present the industry is in a languishing condition, so that farmers in the areas affected have turned, and are adjusting themselves, to other types of farming.

Horses and Mules.—In the Union there were in 1926 about 900,000 horses, 138,000 mules and 796,000 asses or donkeys. Owing to the development of motor traffic in recent years, the horse industry is diminishing. Asses are utilized to a very great extent in the semi-arid sections of the country owing to their hardiness under adverse conditions.

Bees.—Beekeeping is a promising young industry. Much more can be done in this direction than has been the case up to the present. There were 61,000 beehives in 1926, and the production was 657,000lb. of honey, not including that obtained in native locations and reserves.

Transportation, Storage and Marketing.—South Africa has no inland waterways, and this has been one of the great factors in retarding the agricultural development of the country. In the early days, the ox-wagon and stage-coaches were the main types of transportation. Since the end of the nineteenth century, there has been a rapid extension of railway facilities; in 1927 12,600 miles of railway lines (including those in South-West Africa) were open, and an excellent railway service exists between the large inland centres and the main coastal centres, and between the various parts of the country and the larger towns. Since 1925, great progress has been made in the extension of road-motor services in various areas to link up with the railway system. This new development has been, and will continue to be, a great factor in stimulating more intensive farming throughout the country and providing improved marketing facilities. The mileage of roads in the Union in 1924-25 was 67,000; the number of bridges was 715 and the expenditure on roads and bridges was in 1924-25, £1,000,000.

Municipal markets exist in practically all urban centres; the principal municipal markets are at Johannesburg, Cape Town, Durban, Port Elizabeth, East London, Pretoria, Bloemfontein and Kimberley. Cold

storage facilities exist in these principal centres. In the coastal towns, especially Durban, East London and Port Elizabeth, there are many wool-warehouses. Large wool auctions are held at the coast. Johannesburg, Durban, Bloemfontein and Cape Town are the main markets for cattle and sheep sales.

The main agricultural products exported from the Union of South Africa to overseas countries, North and South Rhodesia and South-West Africa for the years 1925 and 1927 were :—

Product.	1925.	1927.
	£1,000	£1,000
Wool	15,095	17,118
Maize	5,673	1,266
Hides and Skins	2,871	3,787
Sugar	881	784
Maize Meal	844	414
Mohair	836	808
Wattle Bark	781	868
Fresh Fruit	760	813
Raw Cotton	350	170
Bark Extract	328	91
Fresh Meat	264	179
Crayfish	242	203
Tobacco—Manufactured and unmanufactured ..	240	116
Ostrich Feathers	204	44
Eggs	182	225
Animal Foodstuffs	156	382
Millet	138	—
Dried Fruit	132	164

The total Union exports of animals, agricultural and pastoral products, foodstuffs, potable wines, raw cotton, amounted to £31,240,000 in 1925, and to £29,356,000 in 1927.

Plate 23.] POTATO CULTURE.

The value of the chief agricultural and pastoral products imported into the Union during the calendar years 1925 and 1927, amounted to £8,420,000 and £9,298,000 respectively. The following are the main items imported :

Item.	1925.	1927.
	£1,000	£1,000
Wheat and Flour	2,000	1,735
Coffee	1,197	916
Tea	791	915
Rice	560	629

The excess of the 1927 exports of agricultural and pastoral products over imports accordingly amounts to approximately £20,000,000.

Manufacturing as related to Agriculture.—The manufacturing industries of an agricultural nature consist of flour mills, tobacco factories, dried fruit packing houses, jam factories, breweries, wine and brandy distilling factories, tanneries and boot and shoe factories, wool washeries, soap and candle factories, bacon and ham curing establishments, butter and cheese factories, saw mills, coach and wagon works. A large proportion of raw agricultural products, to-day exported in the raw state, can undoubtedly profitably be transformed in South Africa into finished articles, and there are unmistakable signs that this will be done to a much greater extent in the near future than is the case at present. A smaller proportion of the European population will then be found in agricultural pursuits, and a larger proportion in manufacturing and industrial callings.

Rural and Agricultural Institutions and Organizations.—Various institutions and organizations are actively engaged in promoting the agricultural and rural interests of South Africa.

The Department of Agriculture.—At Union in 1910, the various agricultural departments were consolidated

into one Department of Agriculture. The Department is modelled largely on the lines of the Department of Agriculture of the United States of America. The Minister of Agriculture is at the head of the Department, and is responsible to Parliament for the policy and acts of the Department. The permanent head of the Department is the Secretary, who is also Accounting Officer; he is responsible to the Minister for the work of the Department, and is assisted by an Under-Secretary. The functions of the Department are administrative, regulatory, research and extension (including education). Apart from the general administrative staff, the main sub-divisions of the Department are :—

1. Animal Industry and Veterinary Services.
2. Plant Industry.
3. Chemistry.
4. Agricultural Economics and Markets (including Co-operation).
5. Agricultural Education and Extension.
6. The Stellenbosch-Elsenburg College of Agriculture of the University of Stellenbosch, responsible for the agriculture of the Winter Rainfall area.

The Onderstepoort Research Station of the Division of Veterinary Services has now been selected as the Central Station for Veterinary Research in the British Commonwealth of Nations.

Under the Division of Agricultural Education and Extension fall the Agricultural Schools at Potchefstroom (Transvaal), Glen (Free State), Grootfontein (Middelburg, Cape), and Cedara (Natal), where one-year agricultural courses for the training of young men are given, and a number of extension officers stationed in various districts of the country.

The Stellenbosch-Elsenburg College of Agriculture of the University of Stellenbosch, and the Faculty of Agriculture of the Transvaal University College, Pretoria, supply higher training in agriculture, leading to academic degrees. The former also gives a one-year course of training, similar to those at the Agricultural Schools falling under the Division of Education and Extension.

There are various sub-stations for experimental and demonstration purposes in different parts of the country.

The annual expenditure of the Department amounts to about £1,000,000, while the revenue received varies from about £100,000 to £150,000. Apart from administrative, general and temporary staff, there are over 400 scientific and technical officers, qualified along various directions of agricultural science, in the service of the Department, giving attention mainly to regulatory, research and educational activities in the various phases of the agricultural industry.

Vocational and General Agricultural Education.—The Union Department of Education has a number of vocational and industrial schools in which agriculture of an elementary nature is taught. The Provincial Educational Administrations are taking steps to introduce agricultural education of an elementary type into the regular school curriculum. Special measures have been taken, in co-operation with the Department of Agriculture, for training teachers of Agriculture for this purpose, at the Schools of Agriculture.

Agricultural Associations.—There are in each of the four provinces of the Union a number of Agricultural Societies and Farmers' Associations, about four hundred in all, having as members a great many of the most influential and progressive farmers. An important function of a number of agricultural societies is the promotion of the various agricultural shows, of which

sixty, or more, are held annually throughout the country. Most of the societies are affiliated to the provincial Agricultural Union in each of the four provinces. The provincial Agricultural Unions each select ten delegates, or representatives, to form the South African Agricultural Union, which meets annually to discuss agricultural matters. The Executive Committee of the South African Agricultural Union, consisting of selected representatives from the provincial Unions, form an Agricultural Advisory Board to advise the Minister on matters relating to agriculture. Various specialized phases of agriculture have special organizations, the most important of which are the South African Citrus Exchange, the South African Deciduous Fruit Exchange, the National Wool Growers' Association, the South African Poultry Association, various cattle societies and societies dealing with other agricultural products. In 1928 the South African Agricultural Union took steps to broaden its Constitution so as to enable specialized commodity societies to affiliate with the Union, and obtain representation on the Agricultural Advisory Board.

Co-operative Enterprises. — On 30th June, 1928, there were registered a total of 376 co-operative societies, having a membership of 58,003.

The Land Bank.—In 1912, the Land and Agricultural Bank of South Africa was established for the purpose of financing co-operative societies, and to make financial advances and loans to farmers for buying land, fencing, constructing dipping tanks and building silos. Since 1912, over £8,000,000 has been advanced to farmers. Under the Agricultural Credit Act of 1926, the Land Bank was further empowered to loan funds to agricultural credit societies, of which quite a number has since been formed.

Plate 24.] CATTLE IN THE SHOW RING, JOHANNESBURG.

Land Settlement.—Provision has been made through various Land Settlement Acts since 1912, for facilities for the purchase, sub-division and disposal of private and company land for settlement purposes, and for the regulation of the allotment of Crown land. At 31st March, 1926, there were over 11,000 debtors on the books of the Department of Lands; a capital sum of over £4,000,000 was due to the Government for land sold, for advances made to settlers and for other advances in connection with land settlement.

Agricultural Information.—The Department of Agriculture has an Agricultural Library at Pretoria, containing about 10,000 agricultural books, and a large number of current agricultural publications and periodicals for the use of departmental officers and farmers. The Department publishes a monthly official organ, "Farming in South Africa," and a monthly publication, "Crops and Markets," both of which reach a large number of farmers throughout the country. The Department also supplies the press of the country with a weekly agricultural news service. In addition, the country is served by a number of excellent private weekly and monthly agricultural papers, such as, amongst others, "Die Landbouweekblad," "The Farmers' Weekly," and "The Farmers' Advocate." Various publications, such as the Official Year Books of the Union of South Africa, the Agricultural Census, The Handbook for Farmers (1929) by the Department of Agriculture, The South and East African Year Book, are rich mines of information and guidance in regard to South African Agriculture. Agriculture in South Africa is only on the threshold of its development, rich stores in every direction are awaiting further exploration and profitable utilization, so that by that means the welfare and prosperity of South Africa may be further stimulated and accelerated.

X.

THE VEGETATION OF SOUTH AFRICA.

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Introduction.—The portion of South Africa dealt with in this brief sketch lies south of latitude 22°. It includes the Union of South Africa, a small portion of Portuguese East Africa, a large part of the South-West African Protectorate, and much of the Bechuanaland Protectorate.

In "Science in South Africa," the Handbook prepared on the occasion of the visit of the British Association in 1905, Dr. Bolus gave a comprehensive account of the Floral Regions of South Africa. He treated the subject mainly from the systematic and floristic point of view, but he dealt also with the progress which had been made in the investigation of the vegetation since the time of Drége (1826-1834). Dr. Bolus called attention to our scanty knowledge of "The Kalahari Region" and "The Western Region", and pointed out the desirability of investigating these districts. Our knowledge of these areas has been considerably increased since 1905, and the advances made are noted in the following account of our vegetation.

In this account, the subject is treated on broad lines from the vegetation angle and the commonly accepted division into desert, grassland and forest is adopted. All three types, or formations, occur in the area which is being reviewed.

Desert.—Desert conditions prevail on the west coast and over a large portion of the interior where the rainfall varies from less than 1 inch to 15 inches. Three types can be distinguished, namely, the Namaqualand Coast desert, the Karroo semi-desert, and the Kalahari desert-grassland transition.

The Namaqualand Coast Desert.—This is a region of drifting and shifting sand dunes, of gravel plains, and barren rock surfaces. It is a narrow coastal belt varying in width from 10 to 80 miles, and stretches from just beyond the Olifant's River in the south to beyond the limits of our northern boundary. Its broadest part is from Luderitz Bay to Conception Bay. It includes all the country lying between the western edge of the Escarpment and the Atlantic Ocean. It is a barren, wind-swept desert composed mainly of vast hills of yellowish sand, and is characterized largely by the presence of stem-succulents. The rainfall in this region is extremely scanty, being under five inches. Over considerable areas rain may not fall for several years in succession. Some five distinct zones of vegetation can usually be distinguished between the escarpment and the ocean, namely, those of the western slopes of the escarpment, the gravel plains, the sand dunes, the rocky hills and the sea shore. On the rocky slopes of the escarpment, *Aloe dichotoma*, *Euphorbia virosa*, *Euphorbia dregeana*, *Sarcocaulon Burmanni*, and *Augea capensis*, characterize the vegetation, while on the gravel plains, which may often be destitute of plants for miles and miles, *Eragrostis spinosa* and *Aristida brevifolia* occur scantily, together with several species of *Sarcocaulon*. On these gravel plains in the north, the famous Tumboa or Welwitschia (*Welwitschia mirabilis*) occurs in association with *Zygophyllum Stapfii*. The sand dunes support a very scanty growth of *Eragrostis spinosa* and *Eragrostis*

cyperoides, while the shore harbours many interesting forms of succulents, including species of *Salicornia* and *Salsola*.

In the river valleys which traverse this coastal belt, the most typical plants are *Acacia giraffae*, *Acacia albida*, *Euclea pseudebenus*, the tamarisk (*Tamarix articulata*), *Combretum primigenum* and *Euphorbia gregaria*, the last often covering vast stretches of low-lying country to the exclusion of almost everything else.

At the coast, where the river mouths frequently become buried in the dunes, *Acanthosicyos horrida* and *Tamarix articulata* occur.

As an offshoot of this desert area, mention must be made of the very remarkable vegetation which characterizes the valley of the Orange River, and extends inland as a narrow belt not more than twenty miles wide, nearly as far as the Aughrabies (King George's) Falls. It is a region of steep, bare and rugged hills, with short dry water-courses and sandy valleys. The rainfall is under 5 inches and is of very irregular occurrence. The vegetation on the tops and higher slopes of these hills is characterized by the remarkable apocynaceous plant, *Pachypodium namaquanum*, and other interesting stem-succulents such as *Ceraria namaquensis*, *Aloe dichotoma*, *Euphorbia virosa*, *Cotyledon paniculata*, *Commiphora saxicola* and a great variety of Sarcocaulons. In the sandy valleys below, either *Euphorbia gregaria* or *Sisyndite spartea* is frequently dominant. Common trees and shrubs in these valleys are *Acacia giraffae*, *Boscia albitrunca*, *Cadaba juncea*, *Euclea pseudebenus*, *Bauhinia garipensis* and *Pappea capensis*.

The Karroo Semi-Desert.—The Karroo semi-desert occupies a roughly club-shaped mass of country in the west and south-west. It covers nearly one quarter of the whole of the country under review. It includes

Bolus' Karroo region, Upper Region, and a considerable portion of his Kalahari region which embraced Namaqualand, Bushmanland and Great Namaqualand.

The area is one which exhibits a great variety of plant associations, and yet it retains throughout its length and breadth a remarkable uniformity in its general appearance and in the plants which are common throughout. Indeed, it is difficult to conceive of a more interesting and fruitful field awaiting the student of ecology than this area.

Karroo beds with their shallow and rich soils cover the southern portion of the area, while granites and gneiss figure largely in the western and northern portions. The average annual rainfall over this area is from under 5 inches to 12 inches, most of which falls during the summer months.

Except in the extreme south where succulents dominate, microphyllous shrubs and shrublets characterize the whole area. Trees common throughout are *Acacia karroo, Pappea capensis, Euclea undulata* and *Boscia albitrunca*.

Typical bushes and shrubs are *Rhigozum trichotomum, Phaeoptilum spinosum, Lycium arenicolum, Nymania capensis* and *Melianthus comosus*; while the shrublets which characterize the area are the karroo bushes (*Pentzia virgata, P. incana* and *P. globosa*, and *Chrysocoma tenuifolia*), *Euryops multifidus, Salsola aphylla*, and *S. Zeyheri*.

The following succulents are common throughout: *Galenia africana, Euphorbia mauritanica, Cotyledon fascicularis, Mesembrianthemum spinosum* and Mesembrianthemum spp.

The country commonly known as "the Karroo" which forms the southern portion of this area is really a shallow oblong basin which lies at an altitude of

2,000 to 3,000 feet. It has dry river beds, shallow soils and exposed rock surfaces. The vegetation is composed mainly of succulent bulbous and tuberous plants. Wide, bare spaces usually occur between the plants. In the western portion, *Galenia africana* and *Euphorbia mauritanica* dominate. The central portion is largely dominated by succulent Mesembrianthemums, whereas in the east, where the rainfall is heavier, succulent Euphorbias, Aloes, Cotyledons and Crassulas form conspicuous associations. In the southern portion there is frequently some tree growth composed of *Euclea undulata*, *Dodonaea Thunbergiana*, *Schotia speciosa*, *Pappea capensis* and *Carissa arduinia*.

The country north of the Karroo, lying above 4,000 feet, is made up largely of wide plains broken by table-topped and pointed hills. The river valleys are dry, while the soils are shallow and usually overlie horizontal rocks. The vegetation is composed almost entirely of low-growing xerophytic shrublets which are commonly referred to as "Karroo bush", and include the bitter karroo bush (*Chrysocoma tenuifolia*) and the sweet karroo bush (*Pentzia incana*), also *Arthrosolen polycephalus*, *Mesembrianthemum spinosum* and other related species. Common shrubs amongst these associations are *Lycium arenicolum* and *Phaeoptilum spinosum*. Where the soil happens to be deep and sandy *Rhigozum trichotomum* may grow to the exclusion of almost everything else.

The central portion of the Karroo semi-desert which includes Bushmanland and Namaqualand is composed of vast arid plateaux and plains. The river beds are usually dry and the soil is bare, being stony and sandy. The vegetation is scanty, and consists of isolated tufts of bunch grasses, stunted bushes and shrublets, on the plateaux and plains, and a few succulents on the rocky hills. The rainfall over the whole area is under 12 inches, and semi-desert conditions prevail throughout. The

granitic soils, where they are deep and sandy, are dominated by the deciduous and xerophilous *Rhigozum trichotomum*, but where they are shallow and the drainage is poor, vast tracts of country are covered by pure growths of *Salsola Zeyheri*. Other typical and well-marked plant associations on the sandy granitic soils are *Augea capensis* and *Aristida brevifolia*. With these two latter associations *Parkinsonia africana* is frequently present. Along the dry rivers in this area the characteristic plants are *Acacia giraffae*, *Pappea capensis*, *Royena pallens* and *Cadaba juncea*. On the hills, wherever the rock outcrops, the most characteristic plant is *Aloe dichotoma*, and with it frequently occur *Euphorbia virosa* and *Euphorbia gregaria*.

North of the Orange River very similar semi-desert vegetation extends northwards to beyond our boundary. The low-lying valleys are, however, frequently dominated by *Euphorbia gregaria*, while *Rhigozum trichotomum* and *Catophractes Alexandri* occur on the sandy soils.

The plateaux composed of Karroo beds are desolate country with a typical karroo-like appearance. They are arid and stony, and are sparsely covered with stunted bushes of *Rhigozum trichotomum*, *Salsola aphylla*, *Zygophyllum flexuosum* and *Mesembrianthemum spinosum*. The plateaux on the granite, however, in this area carry a very different vegetation. Here, the sandy plains are covered mainly with grass. On the shallow soils the short and tufted, small Bushman grass (*Aristida obtusa*) dominates, while on the deeper soils *Aristida brevifolia* and the Bushman grass (*Aristida ciliata*) are dominant.

The Kalahari Desert-Grassland Transition.—This transition region occupies the country commonly known as the Kalahari desert. It is a vast shield-shaped mass of country occupying almost the centre, or heart, of South Africa. It is covered throughout by a thick mantle of sand which is mainly of a deep red colour.

The southern and central portion of this region lies at an altitude of 2,000 to 3,000 feet, while the northern portion is between 4,000 and 5,000 feet. It is essentially a region of undulating, sandy plains and dunes. The latter usually lie in a west-north-west direction and frequently anastomose.

The region is essentially an open formation of perennial and annual grasses, annual herbs, and desert shrubs and trees. The most characteristic tree of the southern portion of this region is *Acacia haematoxylon* which occurs on the sandy plains, on the dunes, and in the low-lying, alkaline soils.

On the deep, sandy plains the tall *Aristida ciliata* usually dominates, or its place may be taken by an annual *Schmidtia*, which covers the country for hundreds of square miles, and gives it the appearance of one vast cornfield. Wherever the sand is shallow and lies above tufaceous limestone, the short *Aristida obtusa* dominates. Mixed with this grass covering are shrubs of Rhigozum, Aizoon, Phaeoptilum and Lycium, while common trees and bushes are *Acacia giraffae, Acacia haematoxylon, Acacia detinens, Parkinsonia africana, Catophractes Alexandri* and *Boscia albitrunca*.

On the dunes the most characteristic grass is *Danthonia suffrutescens* which is associated with *Aristida ciliata, Aristida uniplumis, Schmidtia bulbosa, Eragrostis pallens, Anthephora sp.*, and a bulbous rooted *Digitaria*. Of frequent occurrence on the dunes is *Monechma incana*, while *Citrullus vulgaris* is also typical of this region.

The grasses in this region never form a continuous turf. It is essentially a very open stand of perennial and annual grasses, which always assume a bunched or tufted habit.

Grassland.—Grassland covers the eastern half of South Africa practically wherever the annual summer

rainfall exceeds fifteen inches. Two types can be distinguished, namely, that which occurs as a closed sward and which covers the high-lying country in the Orange Free State and the Transvaal, and which will be referred to as " the South African Steppe ", and that which is of a more open and xerophilous character and is associated with bush and tree growth and forms typical savannah, and which will be referred to as " the South African Savannah." The latter has its greatest development over the northern half of the Transvaal and the southern portion of Portuguese East Africa, and has extended southwards along the south-eastern edge of the Kalahari almost to Prieska, and also between the Drakensberg escarpment and the coast almost to Port Elizabeth. This formation is in a large measure merely an extension of the tropical African flora, which is clearly visible in the constituents of the vegetation covering the northern and eastern Transvaal, Swaziland and Portuguese East Africa, and perhaps is even still more evident in the vegetation of the coastal strip from Portuguese East Africa to East London.

The South African Steppe.—This region occupies a large mass of country immediately west of the Drakensberg escarpment. It includes the south-eastern portion of the Cape of Good Hope, Basutoland, the greater portion of the Orange Free State and the southern half of the Transvaal. Most of the country lies at an altitude of over 4,000 feet. It experiences a summer rainfall, and the dry period coincides with the cold winter season. Considerable frosts are experienced over this area for nearly four months during the dry season, and the climate is, on the whole, fairly uniform over the area.

The region presents a most monotonous type of scenery, as it consists of vast rolling plains and tablelands covered with a dense turf of perennial grasses, and usually devoid of indigenous trees and bush.

Throughout the greater portion of the area the underlying rocks are parallel with the surface, and the soil is deep and of a loamy nature. In Basutoland, however, the country is mountainous and hilly. In the south and west where the rainfall is not so uniform, the grass-sward is naturally more open in character, and the individual plants more bunch-like in habit.

The chief characteristic grass over this whole area is *Themeda triandra*. Other typical grasses which form striking associations in this region are *Andropogon hirtiflorus*, *A. ceresiaeformis*, *A. schiernsis*, *A. nardus validus*, *A. excavatus*, *Urelytrum squarrosum*, *Trachypogon polymorphus*, *Elionurus argenteus*, *Tristachya Rehmanni* and *T. leucothrix*, *Ctenium concinnum* and *Microchloa altera*; growing amongst the grass is a large number of herbaceous plants which seldom rise above the grass level. They are mostly perennials, and die down during the winter, and renew their growth again in the spring either before or with the first rains. Many are provided with large underground stems or tubers in which they are able to store reserve water and food. The best known of these are *Elephantorrhiza Burchellii*, *Erythrina Zeyheri*, *Buphane toxicaria*, *Euphorbia truncata*, *Pentanisia variabilis* and *Raphionacme divaricata*.

The South African Savannah.—Savannah occurs in two widely separated areas in South Africa. It reaches its greatest development in the north-eastern portion of the area under review, while a small extension is met with far away in the west in the neighbourhood of Windhoek. Both can be regarded as extensions of the Tropical African vegetation. Owing to the heavier rainfall in the east, the eastern extension exhibits a much greater variation in its plant associations and their general luxuriance than the western. For the sake of convenience these will be referred to as the Eastern and Western Savannahs.

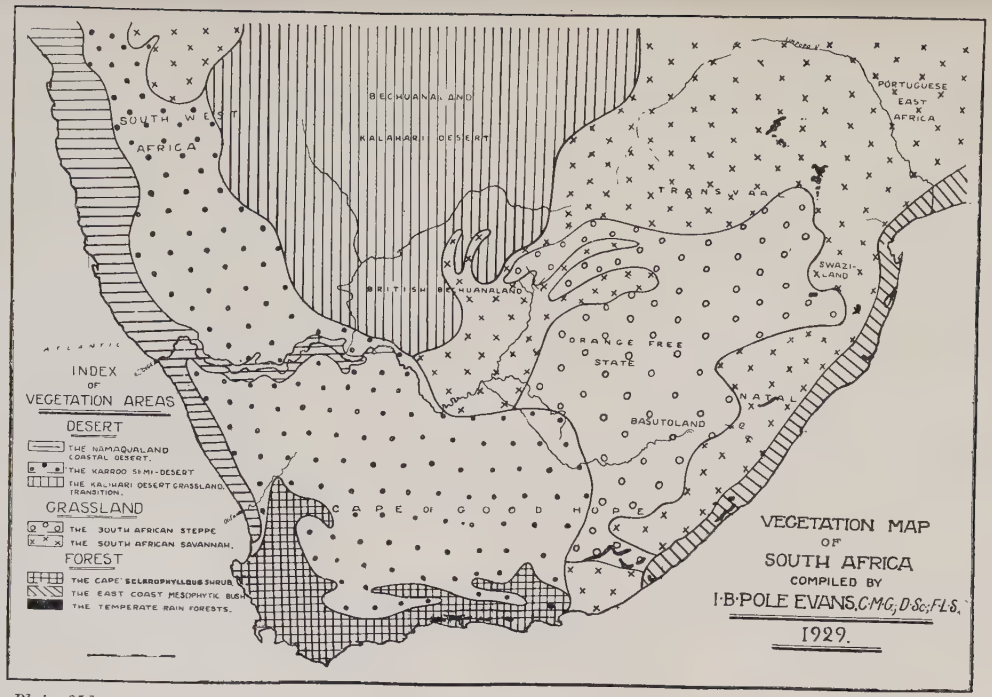

Plate 25.]

VEGETATION MAP.

The Eastern Savannah covers the country lying below 4,000 feet, and is north of the South African Steppe region. It is continued southwards as a fringing belt to this region both on the east and west.

The Western Savannah just reaches our northern limits, and covers the high country surrounding Windhoek at an altitude of 4,000 to 5,000 feet. Over the eastern section the rainfall varies from 15 to 30 inches, while in the west it averages 10 to 20 inches.

In the Eastern Savannah four well-marked associations can be recognised, namely :

(1) a north-eastern deciduous thorn association which I shall describe as the Limpopo deciduous thorn savannah ;

(2) a southern deciduous-evergreen association : the Waterberg deciduous-evergreen savannah ;

(3) an eastern deciduous thorn and succulent association : the Eastern thorn and succulent savannah ;

(4) a western deciduous thorn association : the Griqualand West deciduous thorn savannah.

(1) The Limpopo deciduous thorn savannah covers the wide open valleys of the Limpopo, the Komati, the Umbuluzi and the Maputa rivers and their main tributaries. Here it is composed of open thorn country in which Acacias predominate, and which is characterized by the presence of *Acacia pallens*. It is an area practically devoid of frosts.

Other trees typical of this savannah are : *Combretum porphyrolepis, Bolusanthus speciosus, Schotia transvaalensis, Sclerocarya caffra, Kirkia acuminata, Terminalia prunioides, Lonchocarpus capassa, Balsamodendron africanum* and *Androstachys Johnsoni*. Along the rivers in this area *Acacia albida, Acacia xanthophloea*

and *Sophora zambesiaca* are common. East of the Drakensburg *Afzelia quanzensis, Pterocarpus erinaceus, Kigelia pinnata, Eugenia cordata, Trichilia emetica, Diospyros mespiliformis, Parinarium mobola* and *Cordyla africana* occur in this area. The savannah in the Limpopo Valley itself is, however, characterized by the baobab (*Adansonia digitata*), *Copaifera mopane* and such tropical west African trees as *Maerua angolensis, Pseudocedrela kotschii* and *Balanites aegyptiaca*.

(2) Lying west of the Drakensburg escarpment between the Limpopo valley and the South African steppe region at an altitude of 3,000 to 4,000 feet, is a rather different type of savannah—the Waterberg deciduous-evergreen savannah. It is an area of occasional frosts. Acacias are well represented in this savannah, but the dominant trees are those with broader leaves. Typical amongst these are *Burkea africana, Terminalia sericea, Peltophorum africanum, Combretum Zeyheri, Dombeya densiflora, Rhamnus Zeyheri, Ximenia caffra, Heeria paniculata, Pappea fulva, Faurea saligna, Spirostachys africana, Ochna pulchra, Mimusops Zeyheri, Rhus lancea* and *R. Gueinzii*, and *Lannea discolor*. Many of these are evergreen. Typical grasses in the Limpopo savannah are *Pennisetum cenchroides, Urochloa trichopus, Panicum coloratum* and *Panicum maximum*. These grasses also occur in the Waterberg savannah with *Eragrostis superba, Elionurus argenteus, Dichanthium annulatum, Hyparrhenia Ruprechtii, Urochloa helopus, Brachiaria brizantha, Digitaria eriantha, Aristida uniplumis, Sporobolus Smutsii, Tristachya pedicellata, Schmidtia bulbosa* and *Eragrostis pallens*.

(3) The eastern deciduous thorn and succulent savannah covers the country which lies at 2,000 to 3,000 feet between the coast and the Drakensberg escarpment. It is a region of terraced landscapes and deep valleys with perennial streams. The soil is covered with a

closed grassy turf in which scattered thorn trees occur in the open country, and arborescent succulents in the sheltered valleys. This type of savannah stretches from the valley of the Pongola southwards to the valley of the Sundays River. The rainfall varies from 20 to 40 inches, and frost is experienced over most of the area. In the northern part of this area *Acacia lasiopetala* is characteristic of the savannah, while in the southern portion *Acacia Karroo* is dominant.

Typical arborescent succulents are *Aloe Bainesii, A. Marlothii, A. nitens, A. ferox, A. candelabrum, Euphorbia Cooperi, E. ingens, E. triangularis, E. grandidens* and *E. tetragona.*

The dominant grasses in this Savannah are *Themeda triandra, Andropogon hirtus, A. pertusus, A. amplectens, A. Schoemanthus, Eragrostis plana* and *Sporobolus indicus.*

Common trees occurring in the open country are *Acacia caffra, A. Benthami, Celastrus buxifolius, Erythrina caffra, Cussonia spicata* and *Zizyphus mucronata,* with *Trichilia emetica, Dichrostachys nutans* and *Sclerocarya caffra* in the north only.

(4) The Griqualand West deciduous thorn savannah covers the Orange River valley as far south as Prieska and Hopetown, the valley of the Vaal as far east as Potchefstroom, the valley of the Harts River, the Kaap Plateau, the Asbestos Mountains and the Kuruman Hills. Typical savannah occurs in the open valleys referred to above, and is characterized by the presence of *Acacia giraffae, Acacia litakunensis, Acacia karroo* and *Acacia stolonifera.* On the Kaap plateau and the Asbestos and Kuruman hills the vegetation is more of the nature of a thorn scrub than a savannah. Here, the bush or scrub which averages in height from 6 to 15 feet, is composed mainly of *Acacia detinens, Olea verrucosa, Tarchonanthus cam-*

phoratus and *Rhus tridactyla*. On the Asbestos mountains and the Kuruman Hills the *Lebeckia macrantha* is frequently dominant.

Other common trees and bushes in this area are *Boscia albitrunca, Rhus ciliata, Royena pallens* and *Grewia cana*.

The grasses in this area form an open stand, and are frequently mixed with perennial shrublets such as the karroo bushes (*Pentzia incana* and *Chrysocoma tenuifolia*).

The common grasses are *Schmidtia bulbosa, Anthephora pubescens, Fingerhuthia africana, Aristida congesta, A. Burkei* and *A. uniplumis, Digitaria eriantha var. stolonifera* and *Eragrostis Lehmanniana*.

The Western savannah occupies the extreme north-western portion of the area under review. It includes that part of the South-West African Protectorate which is known as the Highlands of Central Damaraland, and is a rugged, mountainous stretch of country with an average rainfall of 15 inches per annum. The vegetation is composed mainly of thorn bush and succulents. The thorn scrub is made up of *Acacia detinens* and other thorns (*A. dulcis, A. Maras, A. heteracantha*) and several species of *Commiphora. Dichrostachys nutans, Tarchonanthus camphoratus* and *Boscia Pechuelii* also occur. Common succulents associated with this thorn scrub are *Aloe rubrolutea* and *A. hereroensis*.

The dominant grasses are *Aristida ciliata, Pennisetum cenchroides, Enneapogon mollis, Panicum glomeratum* and *Fingerhuthia africana*.

Forest.—True forest covers a very small portion of South Africa, but what is commonly known as sclerophyllous woodland in other parts of the world where warm temperate tracts of country experience wet winters and hot dry summers, is well represented in the south-western portion of the Cape of Good Hope. This type of vegetation will be referred to as "The Cape sclerophyllous shrubs."

Apart from this, high forests occur in the south in the districts of George and Knysna, where the annual rainfall averages 40 to 45 inches, and falls fairly uniformly throughout the year. They also occur in the eastern escarpment where the summer rainfall varies from 40 to 70 inches, and where the edaphic conditions are favourable to tree growth. These forests will be referred to as " The temperate rain forests."

Another type of forest growth is met with on the east coast where the rainfall averages from 40 to 50 inches during the summer months, and where the climatic conditions are of a more tropical character. This will be referred to as " The East Coast mesophytic bush."

The Cape Sclerophyllous Scrubs.—This is a mountainous region with a great variety of soil and climate, and one in which edaphic influences undoubtedly play a most important part. The vegetation is composed of sclerophyllous bush and shrublets, succulents and bulbous and sedge-like plants. The region occupies an angular strip of country at the south-western extremity of the sub-continent. Its northern arm extends as far as the Bokkeveld mountains with an outlier on the Kamiesberg, while its eastern extension reaches the Sundays River valley. In the north it is separated from the Karroo semi-desert by a chain of mountains including the Giftbergen, Nardouw, Cedarberg, Cold Bokkeveld, Hex River, Zwartberg, Baviaan's Kloof, Elandsberg and van Stadens. The country as a whole is mountainous, the mountains being rugged and their vegetation sparse.

The average annual rainfall is about 29 inches, though great variation occurs; for instance, on the slopes of Table Mountain, at Newlands, the rainfall is between 60 and 70 inches, while on the mountains at French Hoek it is considerably over 100 inches. Over the West coast and as far south as Cape Agulhas 60 per

cent. of the rainfall occurs during the winter months, while over the rest of the area 40 to 60 per cent. of the rain falls during the summer months.

The rocks covering the western portion consist mainly of sedimentary and igneous formations of the pre-Cape System with Table Mountain Sandstone, while the remaining portion is composed of the Bokkeveld beds and Table Mountain Sandstone. The soils derived from the pre-Cape sedimentary rocks and the Table Mountain Sandstone are very deficient in plant food, whereas the Bokkeveld beds, which occur mostly in the valleys, are much richer. There is, therefore, in this region an extraordinary variation in the climatic, physical and soil conditions of the country, with the result that nowhere in South Africa is such a rich and varied flora to be found. It may safely be said that in this narrow strip of country, unique facilities exist for studying many problems of high scientific value. One of the most striking features of this area is that some genera of plants such as *Erica*, *Oxalis*, *Pelargonium*, *Phylica*, *Aspalathus* and *Cliffortia* seem to have run riot and expanded beyond all bounds. It is the best known botanically of all the regions in South Africa, and has been very fully and ably dealt with both by Marloth and by Bolus.

The general plant covering of the country is composed of small leaved shrubs and bushes, amongst which grow an abundance of bulbous plants, with here and there a fair sprinkling of succulents. Grasses are few, but Cape grasses (Restiaceae) and sedges are much more abundant. The vegetation is of a decidedly open nature.

The rocks along the coast harbour Aloes, Stapelias and Mesembrianthemums, while the sand dunes are covered with *Mundia spinosa*, *Chymococca empetroides*, *Rhus crenata* and *Myrica cordifolia*.

Typical of the low bush or scrub on the sandy flats are *Euclea racemosa*, *Psoralea bracteata*, *Protea mellifera* and *P. scolymocephala*, *Leucospermum conocarpum*, *Metalasia muricata*, *Pelargonium gibbosum*, *Restio eleocharis*, *Carex arenaria*, *Eragrostis spinosa*, *Eragrostis cyperoides* and *Ammophila arundinacea*.

The inland valleys and plains are usually covered with the *Elytropappus rhinocerotis*, and associated with it are *Eriocephalus umbellatus*, *Athanasia parviflora*, *Euryops tenuissimus*, *Stoebe cinerea*, *Colpoon compressum*, *Polygala myrtifolia*, *Dodonea Thunbergiana*. *Zantedeschia aethiopica* and *Prionium serratum* are conspicuous in the marshes.

Heaths of great beauty often take possession of the hills and mountain slopes, and are frequently associated with taller bush which may be composed of *Leucadendron argenteum*, *Protea mellifera*, *P. lepidocarpodendron* and *P. neriifolia*, *Olea verrucosa*, *Rhus tomentosa*, *Myrsine africana*, *Protea grandiflora*, *Leucospermum conocarpum*, *Leucadendron plumosum*, *Mimetes lyrigera*, *Passerina filiformis*, *Pelargonium cucullatum* and *Berzelia lanuginosa*.

The vegetation in this region is unique in the continent of Africa, and it is an astonishing fact that it shows its greatest affinity, so far as families are concerned, with the flora of South-west Australia, although in type and general appearance it resembles more the Macchia of the Mediterranean. The families typical of this region are Proteaceae, Restiaceae, Ericaceae, Penaeaceae, Grubbiaceae, Bruniaceae, Rutaceae and Iridaceae.

The East Coast Mesophytic Bush.—This is a region of drowned valleys and sandy dunes, which are covered with dense, often impenetrable bush, isolated evergreen forests, tall grasses and palms. It is a comparatively narrow strip of country which stretches from East London northwards to beyond our boundary. The

greater portion lies just above sea-level, and seldom extends inland beyond an altitude of 800 feet. The rainfall varies from 30 to 50 inches, most of which falls during the summer months. Frosts seldom, if ever, occur. The vegetation has a decidedly semi-tropical character in the south, and becomes distinctly more tropical northwards. The region is characterized by the presence of palms and mangroves. The wild date palm (*Phoenix reclinata*) and the ilala palm (*Hyphaene crinita*) occur throughout the region, but the endemic Pondoland coco-nut palm (*Jubaeopsis caffra*) is found only in Pondoland. In the southern portion tall, arborescent succulents occur on the edge of the thick bush, such as *Aloe africana*, *A. pluridens*, *A. ferox*, *Euphorbia grandidens* and *E. tetragona*, while towards the north they are replaced by *Aloe Thraskii*, *A. sessiliflora* and *Euphorbia Cooperi*. The wild banana (*Sterlitzia augusta*) is typical of this bush which also shelters *Dracaena Hookeri* and many shade-loving plants. Several species of Encephalartos also occur in the bush as well as *Stangeria paradoxa*.

The mangroves in this region, which characterize the mud swamps, are *Avicennia officinalis*, *Rhizophora mucronata*, *Bruguiera gymnorrhiza* and *Ceriops Candolliana*, and the tree mallow (*Hibiscus tiliaceus*) is usually associated with them.

Typical trees and shrubs are *Albizzia fastigiata*, *Mimusops caffra*, *Harpephyllum caffrum*, *Milletia caffra* and *Carissa grandiflora*.

In the south of this region, forests of *Boxus Macowani*, *Elaeodendron croceum*, *Ptaeroxylon utile*, *Umtiza Listeri*, *Trichilia emetica*, *Ekebergia capensis*, *Faurea McNaughtonii*, *Cyclostemon argutus* and *Heywoodia lucens* occur, while in the north, forests of *Androstachys Johnstoni*, *Brachystegia spicaeformis* and *Landolphia Kirkii* are common. Typical grasses associated with this mesophytic

bush are a great variety of Panicums such as *Panicum aequinerve, P. chusqueoides, P. filiculme, P. hymeniochilum, P. perlaxum* and *P. zizanioides*, also many Andropogons such as *Andropogon halepensis* var. *effusus, A. rufus* and *A. filipenulous*, and *Ischaemum fasciculatum* var. *arcuatum* and *Erianthus capensis*. These occur in the open, but in the shade *Setaria sulcata, Oplismenus africanus, Panicum laticomum* and *Potamophila prehensilis* are characteristic. They all give the bush a tropical impress.

The Temperate Rain Forests. — The temperate rain forests occur on the south coast in the districts of George and Knysna, and on the eastern escarpment, where the rainfall reaches from 40 to 45 inches in the former case, and from 40 to over 70 inches in the latter case.

A small patch of forest also occurs in the south-west on the Cedarberg Mountains where the famous *Widdringtonia juniperoides* (Clanwilliam cedars) are found.

These temperate rain forests are composed of high timber trees which are mostly evergreen and broad-leaved. They are composed largely of *Podocarpus latifolius, P. Henkelii, P. falcatus, Ocotea bullata, Olea laurifolia, Apodytes dimidiata, Nuxia floribunda, Cunonia capensis*, and *Curtisea faginea*, while in the north, in the Transvaal and Swaziland, the Drakensberg forests are invaded by such tropical trees as *Xymalos monospora, Anthocleista zambesiaca* and *Adina Galpinii*.

Lianes and epiphytes are plentiful in these forests throughout.

In concluding this all too brief sketch it is only right and fitting that mention should be made of those South Africans, who by their labours in the field or in the

herbarium, have materially advanced our knowledge of the country's vegetation since 1905. They are :—

R. S. Adamson (ecology of Table Mountain) ; R. A. Aitken and G. W. Gale (flora of Zululand) ; J. W. Bews (ecological work on the vegetation of Natal, South African grasses, plant distribution) ; Louise Bolus (flora of the Cape Peninsula, efforts to popularize the study of the Cape Flora) ; J. Borle (Portuguese East and Belgian Congo plants) ; Averil Bottomley (cryptogams) ; J. Burtt-Davy (flora of the Transvaal) ; A. Dieterlen (Basutoland plants) ; K. Dinter (S. W. African succulents) ; Ethel Doidge (parasitic bacteria and fungi, South African Ascomycetes and Uredineae) ; R. A. Dummer (Lotononis, Bruniaceae and Rutaceae) ; A. V. Duthie (Eriospermum, flora of Stellenbosch) ; H. G. Fourcade (flora of the Humansdorp district) ; E. E. Galpin (presentation to the State of his extensive collection of preserved plants from south, west and tropical Africa, flora of the Springbok Flats) ; R. Glover (Acacia) ; Marguerite Henrici (mineral content and deficiencies of our indigenous pasture grasses) ; H. Junod (Northern Transvaal and Portuguese East Africa plants) ; T. M. Leslie (fossil flora); M. Levyns (Cape Peninsula flora, ecological studies at Stellenbosch) ; R. Marloth (" Das Kapland," " The Flora of South Africa," bequeathment to the State of his valuable and extensive herbarium) ; C. E. Moss (nomenclature of South African plants) ; G. Nel (Hypoxis) ; the late H. H. W. Pearson (Welwitschia, account of journeys through S. W. Africa and Angola, endeavours in establishing a National Botanic Garden at Kirstenbosch) ; the late Alice Pegler (flora of the Kentani district) ; John Phillips (ecology of the South African forests) ; E. Percy Phillips (flora of Basutoland, the Proteaceae, the Genera of South African Flowering Plants) ; E. Pillans (Restiaceae, flora of the Cape Province) ; R. Pott (Transvaal flora) ; G. Rattray (flora of East London) ; F. A. Rogers (collections from

the Transvaal); Selmar Schonland (origin of our flora, the Flowering plants of the Albany and Bathurst Districts and the Divisions of Uitenhage and Port Elizabeth, Cyperaceae); T. R. Sim (forest flora and forest resources of Cape Colony and Portuguese East Africa, liverworts, mosses and ferns, bequeathing the latter plants to the State); C. A. Smith (flora of the Fauresmith District); Sydney Stent (South African grasses); Edith Stevens (algal flora of South Africa); H. H. Storey (virus diseases of plants in the Transvaal and Natal); T. P. Stokoe (flora of the mountain ranges in the south-western Cape Province); George Thorncroft (plants at Barberton); J. Thode (Natal plants); the late W. Tyson (South African seaweeds); Inez Verdoorn (Crotalarias); H. A. Wager (mosses and liverworts); M. Wilman (flora of Griqualand West).

GLOSSARY OF COLLOQUIAL NAMES OF PLANTS.

Acacia albida : Anaboom.
Acacia detinens : Haakdoorn.
Acacia giraffae : Kameeldoorn.
Acacia haematoxylon : Vaal Kameeldoring, Kaboom.
Acacia karroo : Doornboom.
Acacia litakunensis : Haak-en-steek.
Acacia pallens : Knoppiesdoorn.
Acacia stolonifera : Terassibos.
Acacia xanthophloea : Fever-tree.
Acanthosicyos horrida : Naras.
Adansonia digitata : Baobab.
Adina Galpinii : Water matome.
Afzelia quanzensis : Mahogany Bean tree.
Albizzia fastigiata : Flat crown.
Aloe dichotoma : Kokerboom.
Ammophila arundinacea : Sandhaver.
Anthephora pubescens : Blaauwbuffels gras.
Anthocleista zambesiaca : Cabbage tree.
Apodytes dimidiata : White pear.
Aristida brevifolia : T'waa gras.
Aristida Burkei : Steek gras.

Aristida ciliata : Bushman grass.
Aristida congesta : Steek gras.
Aristida obtusa : Bushman grass.
Aristida uniplumis : Steek gras.
Arthrosolen polycephalus : Besem-bos.
Augea capensis : Baviaan's kos.
Berzelia lanuginosa : Kolkol.
Bolusanthus speciosus : van Wyk's hout.
Boscia albitrunca : Witgat.
Boscia Pechuelii : Witgat.
Buphane toxicaria : Gifbol.
Boxus Macowani : Cape Box.
Burkea africana : Wilde syring.
Cadaba juncea : Swartstorm.
Carex arenaria : Segge.
Carissa arduina : Num-num.
Carissa grandiflora : Amatungulu.
Chymococca empetroides : Dronkbos.
Chrysocoma tenuifolia : Bitter karroo bush.
Citrullus vulgaris : Tsamma.
Colpoon compressum : Sumach.
Copaifera mopane : Mopane.
Combretum primigenum : Hardekool.
Combretum porphyrolepis : Hardekool.
Combretum Zeyheri : Rooibos.
Cotyledon fascicularis : Boterboom.
Cunonia capensis : Rooi els.
Curtisea faginea : Assegai wood.
Cyclostemon argutus : Bastard black ironwood.
Dichrostachys nutans : Sikkelbos.
Digitaria eriantha : Krulgras.
Diospyros mespiliformis : Matome.
Dodonaea Thunbergiana : Bosyzerhout.
Dombeya densiflora : Drolpeer.
Elaeodendron croceum : Saffraan.
Elephantorrhiza Burchelii : Elandsboontje.
Elytropappus rhinocerotis : Rhenoster bush.
Ekebergia capensis : Essenhout.
Eragrostis cyperoides : Steekriet.
Eragrostis Lehmanniana : Soetgras.
Eragrostis spinosa : Voëlstruisgras.
Eriocephalus umbellatus : Kapokbos.
Erythrina Zeyheri : Ploegbreker.
Euclea pseudebenus : Ebbehout.
Euclea racemosa : Kersebos.
Euclea undulata : Guarri.
Eugenia cordata : Waterhout.

Euphorbia dregeana : Melkboom.
Euphorbia gregaria : Aggennys Euphorbia.
Euphorbia mauritanica : Geel melkbos.
Euphorbia truncata : Vingerpol.
Euphorbia virosa : Gifboom.
Euryops multifidus : Harpuisbos.
Faurea McNaughtonii : Beukenhout.
Faurea saligna : Beukenhout.
Fingerhuthia africana : Kalk gras.
Galenia africana : Kraalbos.
Grewia cana : Rosyntjebos.
Harpephyllum caffrum : Kaffir plum.
Heeria paniculata : Respies.
Heywoodia lucens : Cape ebony.
Hibiscus tiliaceus : Tree mallow.
Hyphaene crinita : Ilala palm.
Jubaeopsis caffra : Pondoland coco-nut palm.
Landolphia Kirkii : Rubber-vine.
Lannea discolor : Dikbas.
Lebeckia macrantha : Ystervarkbos.
Leucadendron argenteum : Silvertree.
Leucadendron plumosum : Tolbos.
Leucospermum conocarpum : Kreupelhout.
Lycium arenicolum : Kriedoring.
Melianthus comosus : Kruidje-roer-my-nie.
Mesembrianthemum spinosum : Vyebos, Doring vyebos.
Metalasia muricata : Blombos.
Milletia caffra : Umzimbeet.
Mimetes lyrigera : Rooi stompie.
Mimusops caffra : Red milkwood.
Mimusops Zeyheri : Moepel.
Mundia spinosa : Duinebos.
Myrica cordifolia : Wax-berry.
Myrsine africana : Mirting.
Nuxia floribunda : Wild elder.
Nymania capensis : Klapperbos.
Ochna pulchra : Sandblinkblaar.
Ocotea bullata : Black stinkwood.
Olea laurifolia : Black ironwood.
Olea verrucosa : Olyvehout.
Pappea capensis : Bergpruim.
Pappea fulva : Bergpruim.
Parinarium mobola : Mobola plum.
Parkinsonia africana : Lemoendoring.
Passerina filiformis : Bakbos.
Pelargonium cucullatum : Wilde malfa.
Pelargonium gibbosum : Gouty geranium.

Peltophorum africanum : Huilbos.
Pentzia globosa : Karroobos, Karroo bush.
Pentzia incana : Sweet Karroo bush.
Pentzia virgata : Sweet Karroo bush.
Phaeoptilum spinosum : Brosdoring.
Phoenix reclinata : Wild date palm.
Podocarpus falcatus : Yellow wood.
Podocarpus Henkelii : Yellow wood.
Podocarpus latifolius : Yellow wood.
Polygala myrtifolia : Langeleden.
Prionium serratum : Palmiet.
Protea grandiflora : Waboom.
Protea mellifera : Suikerbos.
Protea scolymocephala : Suikerbos.
Psoralea bracteata : Skapbostee.
Ptaeroxylon utile : Sneezewood.
Pterocarpus erinaceus : Kajatenhout.
Restio eleocharis : Besemriet.
Rhamnus Zeyheri : Red ivory.
Rhigozum trichotomum : Driedoring.
Rhus Gueinzii : Kareeboom.
Rhus ciliata : Karee.
Rhus crenata : Kraaibos.
Rhus lancea : Kareeboom.
Rhus tomentosa : Kreutebos.
Rhus tridactyla : Suurkaree.
Royena pallens : Blaauwbos.
Salsola aphylla : Ganna.
Salsola Zeyheri : Blomkool ganna.
Sarcocaulon Burmanni : Bushman's candle.
Schmidtia bulbosa : Sandkweek.
Schotia speciosa : Boerboon.
Schotia transvaalensis : Boerboon.
Sclerocarya caffra : Maroola.
Spirostachys africana : Tambootie.
Sterlitzia augusta : Wild banana.
Stoebe cinerea : Slangbos.
Tarchonanthus camphoratus : Vaalbos.
Terminalia sericea : Vaal boom.
Themeda triandra : Rooigras.
Trichilia emetica : Cape mahogany.
Umtiza Listeri : Umtiza.
Welwitschia mirabilis : Tumboa.
Widdringtonia juniperoides : Clanwilliam cedar.
Ximenia caffra : Suurpruim.
Xymalos monospora : Lemonwood.
Zantedeschia aethiopica : Varkblom.
Zygophyllum flexuosum : Skilpadbos.

XI.

FAUNA OF SOUTH AFRICA.

By HERBERT LANG, assisted by AUSTIN ROBERTS, V. FITZSIMONS, M. Sc., and G. VAN SON, B. Sc.

Introduction.—The distribution of recent South African animal life can only be understood as an integral part of Africa by glancing backward into geological history. As one of the oldest and most compact of large land-masses, Africa, on account of its relatively great ecological stability, presented a marvellous breeding ground and an evolutionary centre for many creatures.

No real barriers, such as high, extended mountain ranges, opposed the roving instincts. Though most of the area was hot and warm, and climatically fairly uniform, a great diversity of local physiographic conditions offered to many creatures an unrivalled field for adaptive radiation, as may be observed among the great variety of Antelopes. The flora showed an exceptional poverty of luscious fruits and nutritious seeds, which imposed restriction on many creatures, but offered ideal conditions for countless grazing and browsing mammals.

Roughly speaking, there are in all Africa but three kinds of habitats: the deserts and arid areas; the savannah including all sorts of veld and bush-covered regions; and the actual forests. Among the latter, the greatest is the West African Equatorial Rain Forest, a belt about 400 miles wide and 1,800 miles long. It is the most important barrier to distribution of animal life adapted to drier portions of Africa.

Though in the Quaternary many South African mammals reached to North Africa and beyond into Eurasia, most of our recent fauna is limited to the Ethiopian Region, south of the Sahara. With no glaciation in

South Africa since the Palaeozoic, and probably only temporary Pleistocene ice barriers reaching from the north into the eastern and the extreme western equatorial regions, there remained a land area in the south, exhibiting a relatively great constancy of warm climate. As a result, the persistence of types in many orders is surprisingly great, especially in the southern parts.

The enormous range of many types of African animals, over the savannah region from the Cape Province to Senegambia or further north into the Mediterranean Region of North Africa, is accounted for, not only by the absence of physical barriers, but mainly by the enormous length of time during which distribution could proceed in a relatively uniform, mild climate. Conditions of moisture, upon which zoo-botanical distribution depends, are the most outstanding factors of distribution. North and south of the equator, dry or wet zones have left their characteristic impress upon animal and plant life. During the rigours of the colder season, the effects of aridity are much accentuated. They cause certain birds to migrate, but aestivation and hibernation are in South Africa common in most orders, even among mammals.

Mammals.—Above the strata, in the Karroo System, containing the mammal-like Cynodontia, during the long ages of the Mesozoic, some theropodous, ornithischian and a few pseudosuchian Dinosaurs flourished in the Red Beds forming the summit of the System. Gigantic Sauropoda attained their maximum size in the Tendaguru Beds of the Lindi-formation, Tanganyika Territory. But, soon after the Neocomian period, disaster overtook the gigantic creatures of the Age of Reptiles in these southern parts. Probably sinking land-masses in the south caused important isostatic movements in the land surface, and the uplifts were evidently responsible for the rapid drainage of the extensive lacustrine and marshy haunts in which some of these enormous creatures sported in a semi-buoyant state. Their loosely jointed limbs were not

capable of supporting their enormous bulk on land. Changes affecting their food supply and general welfare must have brought about their rapid extinction and made room for the great expansion of mammalian life.

The discoveries of primitive fossil mammals in early Tertiary beds of the Fayum in Egypt are interesting as proving that Africa has been the evolutionary centre of several important groups of mammals. Noteworthy among these are the ancestral forms of Dassies (*Saghatheriidae*), of Elephants (*Moeritherium*, *Barytherium*, *Palaeomastodon*) and of Seacows (*Eosiren*).

That Africa, though repeatedly receiving invasions from the north, has maintained a very characteristic mammalian fauna is proved by Mid-Tertiary fossils from Eastern Africa and especially by those discovered by Dr. Beetz in the diamond fields of the South West.

Fossil remains, referred by Stromer to the Hystricoidae, indicate that already in Mid-Tertiary times they were well established in South Africa. Zoo-geographically and genetically, this fact is of importance, since this group is also known from the Oligocene of Egypt and Europe. The latter types were generally considered ancestral to Neotropical forms. How much earlier they may have appeared in South Africa, it is impossible to state. They evidently were in ideal surroundings, since they maintained their firm hold on the Ethiopian Region.

Among other peculiar fossils from the South West, mention may be made of a specialized Hyaenodontid, very primitive small Suidae and a large Hyracid (*Prohyrax*). Among the several Rodents, a small, ancestral Spring-hare (*Parapedetes*) was already as good a jumper as its large modern ally (*Pedetes*).

The arid regions of the South West are still inhabited by modern forms distantly allied to the fossils, such as the Gemsbok (*Oryx*), Spring-hare (*Pedetes*) and Dassies (*Procavia* and *Heterohyrax*).

There is some evidence in South Africa of the survival of various characteristic Miocene animals. These are either the same specifically or generically, or, in the case of mammals, are more or less distantly related to those living now in karroid regions. Considering other fossil finds of mammals in Africa from the same and earlier strata, the conditions revealed are such that, on faunistic grounds, a distinct Ethiopian Region and a South African Sub-region may have existed even in Tertiary times.

Evidence of the greatness of former mammalian life from a more recent period, has been rapidly gathering during the last two decades. Of this large variety and number of gigantic and ponderous beasts, including Mastodons, primitive Elephants, Antelopes, a Giraffe, large Hippopotami, gigantic Buffaloes and Horses, there has been slowly discovered a wonderland of adaptive radiation in the south.

Most of the recent mammals of the South African Sub-region are remarkably well characterized. No other part of the world appears to have offered such stability in general ecological conditions. The facilities of an almost unrestricted dispersal and settlement in a variety of well-defined habitats produced definite effects. During hundreds of thousands of years of gradual adaptation to environmental conditions, even the largest mammals and the greatest wanderers have differentiated into regional forms. Slow-breeding, larger mammals with roving tendencies naturally show the greatest individual variations. Since olden times the ever-recurring droughts of this mainly sub-tropical country enforced seasonal migrations. Such environmental, nutritional and functional changes fostered a certain plasticity and allayed ordinary selective processes. Yet, for many reasons, the more interesting adaptive radiations are presented by the smaller mammals. Generations of these may be born and perish within an area covered by the shadow of a single tree. In such relatively permanent

conditions, they are morphologically stabilized, and prone to develop endemic types or, at least, local forms. By far the largest number of indigenous species of South African mammals are, therefore, found among smaller forms which live in dry, arid and sandy regions. Others, however, occur in different sorts of veld, among kopjes, in mountains, forests and moist areas.

According to an unpublished check-list of South African mammals, about 400 species, and, including the sub-species, about 675 forms are recognized. These are distributed over 15 orders, 44 families and 187 genera. Of 14 endemic families of recent Ethiopian mammals, only the Rock-rats (Petromyidae) are indigenous in our Subregion. Ten others, however, are well represented; these are the Golden Moles (Chrysochloridae), the Aardwolf (Protelidae), Hippopotamus (Hippopotamidae), Giraffes (Giraffidae), Aardvark (Orycteropodidae), Dormice (Graphiuridae), Spring-hares (Pedetidae), Mole Rats (Bathyergidae), Cane Rats (Thryonomyidae) and Elephant Shrews (Macroscelididae).

Twenty-eight genera are endemic in the Sub-region, of which 20 occur in dry and arid regions. Worthy of mention are the small Carnivora (*Cynictis*, *Paracynictis*, *Suricata* and *Microfelis*), the White-tailed Wildebeest (*Connochaetes*), the Vaal Rhebok (*Pelea*), and the Grysbok (*Nototragus*). Even in mammals, adaptive radiation reaches its climax in the arid sandy regions or dry montane areas, usually among strongly xerophytic vegetation.

On the other hand, tropical genera invading the Union were found to be more numerous than was formerly believed. Noteworthy among these are the medium-sized Elephant Shrew (*Petrodromus*) in Zululand, the Giant Rat (*Cricetomys*) in Zoutpansberg and the Crevice Bat (*Platymops*) in the Transvaal and Damaraland.

A wider distribution, of what were formerly considered essentially South African types, has been recorded for the Spring-hare (*Pedetes*) which is now known as far

north as Nairobi, Kenya Colony, and the Ground Squirrel (*Geosciurus*) which is found in Mossamedes. The most remarkable discovery, however, was a mountain form of the Nyala (*Nyala*), which was found in 1908 by Buxton in Gallaland, Abyssinia. Heretofore the rare Nyala, one of the most beautiful of all Antelopes, was known only from bush country in Portuguese East Africa, the eastern Transvaal and north-eastern Zululand.

Some mammals occurring in the drier parts of South Africa have also representatives in the humid West African Rain Forest. These are the Giant Scaly Anteater (*Smutsia*), Aardvark (*Orycteropus*), Porcupine (*Hystrix*), Honeybadger (*Mellivora*), Giant Rat (*Cricetomys*), Bush-baby (*Galago*) and Baboon (*Papio*).

Highly interesting facts are disclosed by the interrupted range of several South African mammals. Closely related forms are only met with again much further north. Our nearly extinct White Rhinoceros (*Ceratotherium simum simum*) presents an excellent example. Though formerly common over much of the territory south of the Zambesi, the last few troops are now confined to the 'Mfolozi triangle in Zululand. The other, also much harried race (*C.s.cottoni*), lives 1,200 miles further north, west of the Nile.

Among other mammals having a discontinuous range are the Oryx, the Gazelles (as represented in South Africa by the Springbok), the Nyala, the Mountain Reedbuck (*Redunca fulvorufula*), the Dik-dik (*Rhynchotragus*), the Aardwolf (*Proteles*), the Spring-hare (*Pedetes*) and Gerbils (*Gerbillus*). These are animals inhabiting the dry veld, and do not occur in the more humid intervening tropical regions.

During at least one of the warm interglacial periods in Western Europe, representatives of the African fauna, such as the Lion, Hyaena, Elephant and Rhinoceros, spread over these northern countries, and the Hippo-

Plate 26.] TRANSVAAL MUSEUM, PRETORIA.

potamus was common in the rivers of France, and went as far north as Yorkshire. It is not improbable that during such climatic shifts, important changes have taken place in South Africa, and much of the pride of the great Quaternary mammalian fauna may have then been wiped out.

Birds.—The rapid progress of civilization is naturally affecting the avifauna of South Africa. Some of the larger species have become rare or have been driven farther north, but smaller birds have sometimes benefited. Settlement has now become dense in those parts where food for birds was formerly plentiful. Thus the stately Crowned and Wattled Cranes have become very scarce, even the Stanley or Blue Crane has been decimated, though Herons, Storks and other larger terrestrial birds are still plentiful. The rare Lammergeier (*Gypaëtus ossifragus meridionalis*) is now found only in the most inaccessible mountain fastnesses, where the Black Eagle (*Pteroaëtus verreauxi*) still presents a magnificent sight. Even though the Ostrich has been domesticated in the south, it is still found in a wild state in the settled bush-veld districts.

What surprises the newcomer most is the apparent scarcity of birds. Closer study, however, reveals a much larger variety of species than in Europe, where an abundant food supply sustains large numbers of birds in summer, though in winter food becomes so scarce, that many of them have to migrate. The comparatively uniform climate in South Africa is correlated with a great diversity of ecological conditions, and offers a more varied and evenly distributed food supply to numerous species of birds throughout the year.

The more humid eastern area with its scattered forests, resembles in many parts equatorial conditions, and naturally attracts a great number of tropical birds. The more arid western area, with the Namib desert, is

more isolated by the Equatorial Rain-forest belt, and contains the majority of our endemic genera. The higher mountains along the east and south shelter many peculiar forms; on the highveld the annual grass fires have devastated the vegetation and endemic types occur only in these more protected mountainous regions. On the other hand, a fair number of birds adapted themselves so well to the peculiar and dry conditions of the Karroo, that the only migrants found there are some waterbirds and Palaearctic species.

The most plentiful Palaearctic migrants occurring in South Africa are the European Swallow, Sand Martin, House Martin, Swift, Bee-eater, White Stork, Nightjar, Cuckoo, Roller, Red-backed Shrike, Lesser Grey Shrike, Spotted Flycatcher, Willow Wren, Garden Warbler, Icterine Warbler, Common White-throat, Olive's Warbler, Great Reed Warbler, Marsh Warbler, Sedge Warbler, three Yellow Wagtails, Tree Pipit, Golden Oriole and others.

The two Red-footed and the Lesser Kestrels come to South Africa in great numbers, as well as most of the Palaearctic Charadriines, some of the Scolopacine waders and a fair number of sea birds.

Only a few birds are known to breed in both hemispheres. No differences have as yet been detected by taxonomists as regards the Avocet, Stilt, Black Stork, Grey Heron, Purple Heron, Little Egret, Squacco Heron, Night Heron, Wahlberg's Eagle, Osprey and European and Blue-cheeked Bee-eaters.

Of a few distinctly Palaearctic birds, definite subspecies are recognized in South Africa. These are: Cape Quail (*Coturnix coturnix africana*), Kurrichaina Hemipode (*Turnix sylvatica lepurana*), Moorhen (*Gallinula chloropus brachyptera*), Baillon's Crake (*Schoenocrex pusilla obscura*), Cape Dabchick (*Poliocephalus fluviatilis capensis*), Black-necked Grebe (*Proctopus nigricollis gurneyi*), Great Crested

Grebe (*Podiceps cristata infuscata*), Whiskered Tern (*Chlidonias leucopareia delalandei*), Great White Heron (*Casmerodius albus melanorhynchus*), Cape Bittern (*Botaurus stellaris capensis*), White-breasted Cormorant (*Phalacrocora carbo lucidus*), Steppe Eagle (*Psammoaetus nipalensis bradfieldi*), Peregrine Falcon (*Rhynchodon peregrinus minor*), Kestrel (*Cerchneis rupicola rupicola*), Barn Owl (*Tyto alba affinis*) and Stonechat (*Saxicola torquata torquata*).

Several of our birds are regarded by some as distinct species, and by others, as sub-species, of Palaearctic types. These are: Black-backed Gull (*Larus dominicanus*), Gannet (*Moris capensis*), Water Dikkop (*Oedicnemus vermiculatus*), Little Bittern (*Ixobrychus payesi*), Marsh Harrier (*Circus ranivorus*), Cape Kite (*Milvus aegyptius parasitus*), Cape Eagle Owl (*Bubo capensis*), Natal King-fisher (*Ispidina natalensis*), African Hoopoe (*Upupa africana*), and South African Cuckoo (*Cuculus gularis*).

Three Palaearctic birds were introduced early in the present century, and have since established themselves: the English Starling and the Chaffinch at the Cape Peninsula, and the English Sparrow at Durban, whence it has spread to Pietermaritzburg and Zululand. The Indian Myna (*Acridotheres tristis*) has also been established at Durban.

Of the endemic Ethiopian families of birds, occurring within our limits, only the Promeropidae are restricted to this Sub-region. At present, over 600 genera are recognized in South Africa; of these 275 are Ethiopian, while only 41 are endemic. The most strikingly distinct is the Bald Ibis (*Geronticus calvus*) of the Great Eastern Escarpment, where it nests in rocky crevices and on shelves below overhanging precipices. Of other large birds, the Blue Crane (*Tetrapteryx paradisea*) and two genera of Bustards or Korhaans (*Afrotis* and *Heterotetrax*), both

with two species, are confined to the Sub-region and are fairly plentiful. Representatives of two more genera of Cranes and of five Bustards occur within our limits. In spite of an abundance of bird life along our seaboard, only one genus, represented by the Bank Cormorant (*Anacarbo neglectus*) of the southern and south-western coast, does not occur outside South Africa. Although the Cape Cormorant (*Pseudocarbo capensis*) and Penguin (*Spheniscus demersus*) are typically South African, both range slightly north of our limits.

Among the smaller birds two genera of non-passeres are of especial interest, *Geocolaptes* and *Notopicus*, the Ground and the Knysna Woodpeckers; *G. olivaceus* frequents rocks in the southern and eastern mountains; *N. notatus* is found only in the forests of Knysna and a little to the east.

Of the passeres, the most remarkable genus is *Sphenoeacus*, a large grass-warbler, with four sub-species extending from the south to the mountains in south-eastern Rhodesia. Three more endemic warblers (*Eurytila*, *Eremomeloides* and *Priniops*) are met with in the Karroo, the last two extending into Damaraland as well.

Amongst Flycatchers we have three distinct genera, the curious *Lanioturdus* of Damaraland; *Stenostira*, the pretty Fairy Flycatcher of the dry west; and *Sigelus* the Fiscal Flycatcher, which occurs over the central areas of South Africa. Its remarkable resemblance to the Fiscal Shrike may be a case of "mimicry."

Of true Thrushes, of which there are seven species, none are represented by endemic genera in South Africa; but a number of Rock Thrushes and Chats are distinct. Noteworthy are the montane genera, *Chaetops* with two species in the south and east, *Achaetops* in Damaraland, *Pinarornis* with two species in Southern Rhodesia, and *Campicoloides*, *Petrornis* and *Notiocincla* in the south and east. In the dry western plains we may mention four

Plate 27.] WHITE RHINOCEROS.
(*Ceratotherium simum simum.*)

genera of Chats, *Karrucincla* with three forms, *Emarginata*, *Phoenicuroides*, and the pallid *Psammocincla* peculiar to the Namib desert. Amongst the robins there are a number of diverse genera, of which the only one confined to this Sub-region is *Swynnertonia* inhabiting the forests of south-eastern Rhodesia.

Of the peculiar Long-tailed Sugarbirds (*Promerops*) two species are known in the mountainous districts of the south and east, as far north as Gazaland and south-eastern Rhodesia. They resemble the Sunbirds in their habit of coming to the flowers for nectar and insects. Their distribution coincides with certain Proteaceae.

There are sixteen genera of Sunbirds found within our limits, represented by twenty-five species, of which only two are not found in the north. These are the beautiful orange-breasted *Anthobaphes violacea* of the south and *Eremicinnyris fuscus* of the Karroo and dry districts northwards to Damaraland. Larks and Pipits are well represented in South Africa, and, as might be expected, many of them are endemic. Amongst the Pipits, *Hemimacronyx flavus* and *Petranthus crenatus* are confined to the mountains of the south and east. On the highveld, along the Drakensberg, two genera of Larks have been discovered within recent times, *Heteromirafra* and *Botha*, each represented by a single species *H. ruddi* and *B. fringillaris*; while on the plains of the western areas occur *Calendula* with two sub-species in the Karroo; *Calendulauda* is found in the southern "sandveld", *Heterocorys* in the western Transvaal, and the pallid *Ammomanopsis* in the Namib desert.

Only one genus of the many Fringillids and Ploceids is confined to South Africa, namely, the Black-headed Canary (*Alario*) of the dry west. Ten genera of Starlings occur here, but only one of these, *Spreo bicolor*, is endemic. Of the three crows found here, two are distinct, the Black Crow (*Heterocorax capensis*) and White-necked Raven (*Corvultur albicollis*).

In practically all of our characteristic types of country, be it scrubveld, grassveld, Karroo and other arid areas, highveld, bushveld, lowveld, thornveld, forests and mountains, one may travel great distances without seeing any birds, and, yet, in a few places they are extraordinarily numerous.

Along the coast and lagoons, bird life is, at times, very abundant. Particularly noteworthy are the many millions of guano-producing birds, protected on over twenty islands, situated chiefly along the west coast and in the south. Cormorants, Gannets and Penguins are in this respect of great economic importance.

The best South African songsters are among the Rock Thrushes, Canaries, Finches and Shrikes. Here the intensity of sexual emotion seems not to seek interpretation in loud, sustained song. Climatic conditions, or, perhaps, instinctive fear of attracting the attention of numerous enemies may have long ago subdued any exuberant vocal powers in most of our birds. The early riser may, however, be rewarded by many daybreak-choruses.

A few words on the most interesting nesting habits of our birds may be welcomed. The huge, communal nest of Sociable Weavers (*Philetairus socius*) in our arid regions is the most outstanding example, scores of nests being united under the same roof. The mass of thorny twigs of the Buffalo Weaver (*Bubalornis niger*) are also conspicuous, though they are easily outdone by the remarkable, finely woven and long-funnelled nests of other Weaverbirds. The height of gregariousness is reached in the Pink-billed Quelea (*Quelea sanguinirostris lathami*), which nests in colonies of thousands, and lives for the rest of the year in immense flocks, that are the terror of the grain farmer.

Our hornbills (*Bucerotidae*) also arouse attention. The hen bird is plastered up in the cavity of a tree, lays its eggs, incubates them, moults its plumage and only escapes from the voluntary imprisonment after the young are able to fly. During all this time the cock bird supplies ample food for his mate and the young.

In addition to twelve Cuckoos with parasitic habits of egg laying, we have four species of Honeyguides (*Indicatoridae*). The young of the latter develop a sharp hook on the tip of the bill, which is supposed to aid in ejecting the young of the host from such deep nests as those of Barbets and Woodpeckers, in which they are commonly reared. The Honeyguides have the well-known habit of indicating bees' nests to man. Probably this habit was developed by the benefit the birds derived from securing some of the booty, consisting of particles of comb containing young bees.

Viduine Weavers have developed similar parasitic habits of laying their eggs in other birds' nests; *Vidua serena, Anomalospiza imberbis, Steganura paradisea, Linura fischeri, Microchera hypocherina, Hypochera chalybeata* and *Tetraenura regia* rely upon other birds to rear their young. Unlike Cuckoos, these young parasitic Finches do not eject the other young birds, but are reared in amity with them.

Birds of brilliant plumage are far more plentiful here than in Europe. A comparison of such pretty Palaearctic birds as Rollers and Bee-eaters with similar South African species proves this amply. What more beautiful spectacle can be imagined than our resplendent orange-breasted, double-collared and Malachite Sun-birds of the south flitting about the most gorgeous flowers? Such striking forest birds as our ornate Plantain Eaters (Louries), delicate Trogons and the magnificent Emerald Cuckoo can hardly be matched. Even the drabness of our grassy veld is signally enlivened in summer. The

males of some of the Viduine Finches assume a nuptial plumage as handsome as elegant, set off with scarlet or bright yellow. Their peculiar and oft-repeated flight gives the impression of their being eager to display the full charm of their long ornamental tail feathers. Yet, in winter, they assume again the inconspicuous plumage characteristic of their females and young. The long-tailed Widowbird (*Diatropura procne*) furnishes the grandest example ; this and other smaller long-tailed Finches can often be seen from trains.

In the Canaries, where the sexes are usually alike, we find that in the dry west their bright yellow plumage is replaced by a permanent plain one in some species, *e.g.*, *Crithagra albogularis*, and by a plain coloration in the hen and bright yellow in the cock in another species (*Serinops flaviventris*). The Malachite Sunbird (*Nectarinia famosa*) has also a more drab coloration in winter than in summer.

Reptiles.—Approximately four hundred species and sub-species of reptiles have so far been described. Owing to the diversity of physiographic conditions, the many ecological peculiarities and a relatively equable climate, the range of forms is as varied as anywhere in the world.

As regards reptiles, South Africa may be divided into the three following zones :—

(*a*) The eastern portion includes Portuguese East Africa, Southern Rhodesia, the Transvaal lowveld, Zululand, Natal and part of the south-eastern coastal belt. Tropical to sub-tropical conditions admit here a greater number of such widely distributed Central African genera as *Lygosoma*, *Thelotornis*, *Chiromantis*, etc., while *Zonurus*, *Gerrhosaurus*, and the burrowing skinks are some of the typically South African elements.

(*b*) The extensive western portion consists of the Karroo, south-western Cape Province, South-West Africa and Bechuanaland. The many forms adapted for a life in arid regions and deserts, attain their most characteristic

development in the Namib and the Kalahari, and represent the really distinctive portion of the South African reptilian fauna.

(*c*) The central zone comprises all territory between the eastern and western zones such as the Orange Free State and the Transvaal highveld. The fauna of this complex is more nearly allied to that of the western than to that of the eastern area.

Chelonia.—The Mountain or Leopard Tortoise (*T. pardalis*), found in the Karroo and northern Transvaal, is our largest land Turtle, and may attain a length of three feet. The three common marine Turtles, the Leather-back (*Dermochelys coriacia*), Hawksbill (*Chelone imbricata*) and the Loggerhead (*Thalassochelys caretta*) are occasionally encountered on our coasts.

Lacertilia.—The majority of our reptilian fauna consists of lizards, some species occurring in great abundance in certain favourable sites. The Geckonidae, with about fourteen genera, are especially numerous in the west.

The Gerrhosauridae form one of the most characteristic groups of African lizards. *Gerrhosaurus*, so typical of our kopjes and rocky outcrops, may be regarded as truly South African, although two species, *G.flavigularis* and *major*, extend beyond our northern boundaries. Two large species, *G. validus* and *grandis*, which attain a length of two feet, are found only in the eastern zone. *Tetradactylus* and *Cordylosaurus* are confined to South Africa.

The Chamaeleontidae, of chiefly Ethiopian evolution, are mainly distributed over the warmer parts of tropical Africa.

Ophidia.—South Africa, though largely in the temperate zone, has its fair complement of snakes, about 120 species being known ; of these, 25 per cent. are venomous, and capable of inflicting fatal bites. They are more abundant in the humid eastern than in the arid western

areas, where the fauna is restricted mainly to Adders and burrowing forms. The Colubridae form the greater proportion of our ophidian fauna. The family may be divided up into three groups: (1) *Aglypha*, non-poisonous; (2) *Opisthoglypha*, poisonous to a degree; and (3) *Proteroglypha*, highly poisonous.

Of the aglyphous snakes, we have about a dozen genera in South Africa. To this group the following belong: Mole Snake (*Pseudaspis cana*), File Snake (*Simocephalus*), Egg-eater (*Dasypeltis scabra*), Brown Water Snake (*Ablabophis rufulus*) and the Green Water Snakes (*Chlorophis*).

About fourteen genera of the *Opisthoglypha* occur in South Africa, but are largely confined to the central plateau and the eastern zone. The occurrence of the following may be noted: Red-lipped or Herald Snake (*Leptidora hotamboeia*), Striped and Variegated Skaapstekers (*Trimerorhinus tritaeniatus* and *rhombeatus*), Grass and Sand Snakes (*Psammophis*), the Boomslang (*Dispholidus typus*), and the Bird Snake (*Thelotornis kirtlandi*).

Of the highly venomous *Proteroglypha*, there are about seven genera occurring in this country. Of these, the following are the most important: the Sea Snake (*Hydrus platurus*); the Mamba (*Dendraspis angusticeps*), which often attains a length of twelve feet, and is greatly feared owing to the deadly nature of its bite and its great agility and aggressiveness; the Cobras (*Naia*), which are represented by four species, of which the better known are *N. flava*, *haie* and *nigricollis*; and the closely allied Ringhals (*Sepedon haemachates*). The last-mentioned is confined to South Africa; it affects a number of colour varieties, and is greatly feared for its habit of "spitting" venom at its enemies.

Of the Viperidae (*Solenoglypha*), we have three genera (*Bitis, Causus* and *Atractaspis*), all equipped with a highly specialized poison apparatus. Of these, the best known are the Puff-adder (*B. arietans*) and the Horned-adder (*B. cornuta*).

Batrachia.—Taken as a whole, the frogs and toads of South Africa cannot be regarded as particularly numerous, although in some parts a fair number of species is found. Only five batrachian families are represented, the Ranidae, Engystomatidae, Cystignathidae, Bufonidae and Pipidae. Nearly a hundred species are known at present, exhibiting a great variety of form and habit.

Fresh-water Fishes.—Fresh-water fish occur in great numbers in the rivers and great lakes of Central Africa. Extending southwards, however, the number and variety of forms steadily diminish. Since our fish are chiefly related to those of north-eastern and eastern river systems, it is not surprising that the intermittent watercourses of the south-western areas contain but a poor representation. Of about 200 species in South Africa, nearly half belong to the Carp family (Cyprinidae), known locally as Barbels or Geelvis (*Labeo* and *Barbus*). The Witvis (*Cichlidae*) are also fairly numerous, and comprise about a quarter of the total fauna. The remaining quarter includes various forms of Siluridae (Catfish, Platkop or Barber), Mormyridae (Beaked Fish) and Characinidae (Tiger Fish), together with other forms of rarer occurrence. Only a few of our larger forms are palatable and provide a certain amount of sport.

Within recent years, Trout of three species (the Brown, Loch Leven and Rainbow), together with the Leather Carp (*Cyprinus carpio*), have been introduced into our rivers with much success. In certain parts, however, they are now so thoroughly acclimatized, that they threaten to oust our indigenous fresh-water fauna.

Non-Marine Molluscs.—The land and fresh-water Molluscs of South Africa are remarkably heterogeneous, but comprise at least 21 endemic genera. Many of these are well adapted to the arid and semi-arid conditions prevailing over a large portion of the Sub-region. Furthermore, intermittent river systems and seasonal drying-up of swamps and marshes in the interior, have caused a relative poverty of fresh-water types. In addition to the wide-spread Ethiopian and typically East African forms, we have species of Aperidae, Rhytididae, Acavidae and Endodontidae, which have Australian and South American affinities, and may be regarded as vestiges of a Mesozoic Gondwana distribution.

The small, widely distributed fresh-water snails belonging to the families Lymnaeidae, Planorbidae and Physidae have attracted considerable attention, inasmuch as a few of their members influence adversely not only the health of some of our population, but also that of domestic and wild animals. Becker, in 1916, proved that in South Africa *Physopsis africana* is the usual intermediate host of a parasitic trematode, the blood fluke *Schistosoma haematobium*, which is responsible for the disease bilharzia. Cawston's similar researches in Natal, from 1917 to 1923, added much to our knowledge, and Dr. Annie Porter, in 1920, found the cercariae (larval stages) also in *Lymnaea natalensis*.

Arachnida.—The Arachnid fauna of South Africa is particularly abundant in Scorpions and Solifugae, together with the ground-dwelling Spiders. These forms are distributed throughout the region, though the two former groups reach their greatest concentration in the Karroo and dryer areas of the western Sub-region.

Insects.—The insect fauna of South Africa, as compared with that of other parts of the world, is still imperfectly known. Approximate estimates of the number of species were given in 1905 by the late Dr. Peringuey, who supposed it to be about 40,000.

The extensive dry areas of the grassveld, karroo, karroid and desert-like regions present a highly differentiated and extremely well adapted xerophilous insect fauna, with a relatively great number of peculiar and highly specialized forms. On the other hand, the moist and warm north-eastern coastal belt and the mountain forests of the Eastern Escarpment form a natural transition towards the East African Sub-region, and are particularly rich in tropical species. The more temperate southern forest and moister grassland in the south-east have been much less explored, but they appear to contain types closely related to those of neighbouring regions. In the north-western section, the insect fauna resembles far more the adjoining Bechuanaland and Kalahari, than that of northern Angola. In this case the distributional barrier of the West African Rain-forest prevents a strong invasion of West African forms.

Orthoptera.—The "Hottentot Gods" (Mantidae) comprise over a hundred species, and show a great diversity of size and form, from the large *Ischnomantis fatiloqua*, which somewhat resembles a stick-insect, to such minute forms as *Tarachina australis*. Many species simulate flowers (*Harpagomantis*), or dry leaves (*Phyllocrania*), which enables them to escape observation and capture their unsuspecting prey. The generally wingless stick-insects (Phasmidae) are remarkable for their twig- or stalk-like appearance; the largest measures about nine inches in length. Thorn-like excrescences from the body and legs, often arranged asymmetrically (*Bactrododema* spp.), make the deception still greater.

Locusts (Acridiidae) are perhaps the most common among South African insects. Some are conspicuous and others, when startled, give surprise by displaying brightly coloured wings. Notorious are the immense migratory swarms of the Brown Locust (*Locustana pardalina*), which have wrought so much havoc among the crops.

Isoptera.—Some of the numerous termites or " White Ants " are real pests on account of their wood-destroying habits. Among the multitude of structures or "nests", the tall, earthen mounds, or "anthills", in the northern parts of South Africa impart a distinctive feature to the landscape.

Hymenoptera.—The large number of Bees, Wasps and Ants have aroused great interest on account of their much varied habits and economic importance. The Carpenter Bees (*Xylocopa*) belong to the largest South African forms of this order, and tunnel into the beams of houses, tree trunks, stems of aloes and other plants. The Wasps, *Belenogaster*, *Icaria* and *Polistes*, make their paper nests in undisturbed corners of verandas, under rocks or in similar sites. The members of the genera *Eumenes*, *Synagris* and other solitary Wasps use mud, or cement together harder particles in constructing their nests. In these they store caterpillars, spiders and other soft-bodied food for their larvae.

The Ants (*Formicidae*) are as numerous as in most warm countries, and are represented by widely distributed forms. Some are obnoxious to horticulturists especially by transporting many kinds of scale-insects even to the roots of plants.

Lepidoptera.—Among the butterflies (Rhopalocera), only *Meneris*, with three species, and possibly *Leptoneura* are endemic, though the latter has also been taken in Madagascar. Of about fifteen species of *Papilio*, the larger proportion occur in the north-eastern parts, especially in the coastal belt, where *Charaxes* are also abundant.

In the Cape Province, Butterflies are relatively scarce, only the Satyridae and Lycaenidae being predominant. Many collectors, used to European conditions, have been disappointed in the small number of striking Butterflies in spite of the extraordinary wealth of beautiful flowers.

The Moths (Heterocera) are far more numerous and, unlike the Butterflies, include a multitude of endemic forms. Among the Hawkmoths (Sphingidae), the genera *Microsphinx*, *Odontodisa* and *Xenosphingia* are endemic. The Emperor Moths (Saturniidae) are represented by about 60 species, and include the rare endemic *Euchroa trimeni* and *Heniocha grimmia* of the south-western Cape. The Chrysopolomidae are typically Ethiopian, and include our endemic *Ectropa* and many species of *Chrysopoloma*. Some Noctuids are injurious to crops and pastures. Species of *Laphygma*, *Spodoptera* and *Borolia* sometimes multiply to such an extent that their highly destructive larvae have been called " Army Worms" (*L. exempta* and *L. exigua*).

Diptera.—The two-winged flies, as larvae or adults, are mostly scavengers and robbers. While many are harmless and a few even beneficial, some are injurious to man and various animals by causing and spreading devastating diseases. *Anopheles* (*Mysomyia*) *gambiae* (*costalis ?*) is the chief carrier of malaria, a disease occurring mainly in the lowveld, but *pharoensis*, *maculipalpis* and *funestus* are also implicated. Some mosquitos transmit horse-sickness to horses and mules, and, most probably, other diseases to man and animals.

The Horseflies (Tabanidae) furnish the largest number of blood-sucking flies and may convey pathogenic organisms, as in the case of *Haematopota*, though *Stomoxis* (Muscidae) has also been held responsible for transmitting Nagana, a disease fatal to most domestic stock.

Tsetse flies have aroused much attention here as carriers of Nagana. They are represented chiefly by two species, *Glossina morsitans*, now restricted to parts of Bechuanaland, and *G. pallidipes*, occurring in northern Zululand where, as a result, pastoral farming has been rendered extremely difficult.

The " Horse-ticks " (Hippoboscidae) infect certain mammals and birds, and are sometimes apterous. *Hippobosca rufipes* and *maculata* transmit the trypanosome which causes gallsickness in the Transvaal.

Myriapoda.—The Myriapod fauna of South Africa is typically Ethiopian, and comprises about 265 species, of which 84 belong to the Chilopoda (Centipedes), 180 to the Diplopoda (Millipedes), and one to the Symphyla. According to Attems, " the Cape Region is now the best explored of all countries in the southern hemisphere", 62 genera and 175 species being known from this area. The percentage of endemic forms is very high, being just over 85.

Centipedes are not very plentiful in the western area, but are fairly numerous in the Cape Province, Natal and Transvaal.

Crustacea.—Only the fresh-water Crustaceans of the coastal districts and the interior of the Cape Province have been more carefully studied though some forms have also been named from the south-west and parts of the Transvaal.

The Entomostraca, or simpler forms of Crustacea, are well represented. Among the Phyllopoda, several endemic species of that primitive Crustacean type *Apus* are met with in the Karroo and south-western parts, while *A. numidicus* is distributed throughout Africa. Several large forms (*Streptocephalus*) and members of the bivalve *Estheria* group are common in the Cape Province and the Transvaal. Sars, in 1915, recorded 45 species of Water-fleas (*Cladocera*) from the Cape Province belonging to the families Daphniidae, Macrothricidae and Chydoridae. Over 70 species of minute Ostracoda, referred principally to the Cypridae, occur in the Cape Province, the South West and the Transvaal.

A number of characteristic fresh-water Amphipods and Isopods have been discovered in the mountainous districts of the south-western Cape Province. Among the Gammaridea, ten species of mostly blind *Gammarus*, come from the uppermost reaches of streamlets choked with Sphagnum. Another blind Gammarid (*Eucrangonyx robertsi*) has been recorded from the Makapan Caves of the northern Transvaal and surface waters near Irene, Pretoria.

Hirudinea.—Comparatively little is known of the South African Leeches, only about a dozen, mostly aquatic forms, having so far been recorded.

Oligochaeta.—The majority of our native earthworms belong to the families Megascolecidae and Glossoscolecidae, and have mostly been described from the coastal areas of the southern and eastern Cape Province and Natal. In ravines or on forested slopes, they are common under stones and dead wood, but even in dryer areas they are occasionally found under the roots of succulent plants, or in the wet sand around temporary pools of water. The generally small members of the Megascolecidae comprise by far the larger proportion of our oligochaete fauna. The genus *Chilota*, with over 20 species is distributed along the coast from Capetown to Natal, with the majority of forms gathered in the neighbourhood of the Knysna forests. The Glossoscolecidae include the Giant earthworms (*Microchaetus*) of which about a dozen species are known from Natal and Zululand ; some are said to attain a length of five feet.

Museums.—When settlers and colonists moved from the coast inland, South Africa's innumerable herds of game steadily helped to turn the wheels of fortune upon fields of hard won victory. Thus it seems natural that the exceptionally rich fauna and the many interesting discoveries in natural history stimulated from the very beginning a desire in the people for public exhibitions of

representative collections. It is, therefore, appropriate that South Africa should possess relatively more natural history museums than any other country. Museums have been established in the following nine towns: Bloemfontein, Capetown, Durban, Grahamstown, King Williamstown, Kimberley, Pietermaritzburg, Port Elizabeth and Pretoria. Most of the museums include anthropology and ethnography; in some, art objects and historical relics have widened the scope considerably. So impressive and encouraging has been the success of these institutions that some collections, as a basis for new museums, have already been brought together at East London, Harrismith and Colesberg.

With the greater enlightenment of the public and the more stabilized condition of the country, the status of these museums has continually advanced. They are becoming not only more imporant and attractive, in the number and appearance of exhibits, but their scientific and educational activities are steadily expanding.

The most important advance in the South African museums has resulted from the decision of the Government to leave certain museums to local development and to concentrate State support by extending financial assistance to only one museum in each Province: the South African Museum at Capetown, the Transvaal Museum at Pretoria, the Natal Museum at Pietermaritzburg, and the National Museum at Bloemfontein. The directors of these four museums have initiated further progress by establishing close co-operation and avoiding, as much as possible, duplication of scientific research. The practical value of such a procedure in this country is of the utmost importance; it offers the specialists on the different staffs a wider field, broadens their experience, furthers more exact knowledge and renders the accomplishment of sound scientific work possible. This agreement also includes a co-operative organization for field xpeditions.

Zoological Gardens.—The great progress accomplished in recent years in keeping wild animals in captivity, under conditions giving an illusion of absolute freedom and offering a suitable environment, has contributed much to the present world-wide popularity of Zoological Gardens. In these and other respects, Johannesburg has been particularly progressive. In South Africa, the mild climate and a large amount of sunshine render it easy to show a fair selection of the great fauna which from the earliest times has been the chief attraction of explorers, sportsmen and travellers in South Africa.

At present Zoological Gardens exist in the following six towns: Bloemfontein, Capetown (Rondebosch), Durban, Johannesburg, Port Elizabeth and Pretoria. Only the last-named, as the "National Zoological Gardens", receives financial support from the Government, all others being under the respective municipal administrations. Pretoria claims the largest number and most interesting collection of animals (about 1,500). But there can be little doubt that it will soon be surpassed by Johannesburg, where the Zoo has been laid out with remarkable foresight; this park is connected with the Saxonwold, and the animals are the owners of a real fairyland extending over 200 acres. In Durban, the exhibits are practically restricted to birds. This pretty garden lies within the town, and for this reason is somewhat unsuitable for the purpose. An outstanding personal achievement, on the part of Mr. F. W. FitzSimons, the director of the Port Elizabeth Museum, is represented by the Snake Park at Port Elizabeth. At Rondebosch (Groote Schuur) troops of deer roam about in the adjoining woods and Black Wildebeeste and Springboks are kept in large enclosures; other animals are confined in ordinary cages. This establishment owes its foundation to the generosity of Cecil J. Rhodes. The Bloemfontein

Zoological Gardens are situated in a particularly beautiful park. They contain a small, but fine, collection of South African animals.

On the whole, South African Zoological Gardens specialize in bringing a good selection of their own fauna within city limits. In this way, they give the residents and visitors an idea of what they can expect to see in the finest game sanctuary of the world, the Kruger National Park, and in some of the smaller game reserves. An important task undertaken by several of these Zoological Gardens is to assist foreign sister institutions in their endeavour to secure animals from South Africa. In this respect they perform a very laudable purpose, stimulating thereby in many a desire to see for themselves the unsurpassed, great South African fauna.

XII.

GAME RESERVES IN THE UNION AND WILD LIFE PROTECTION.

By HERBERT LANG,

Writing in 1652, Johan van Riebeeck states that the land about Capetown swarmed with eland, hartebeest, kudu and steenbuck ; lions roared defiantly and invaded the cattle kraals at night ; leopards came down from Table Mountain in daylight and carried sheep away from under the eyes of the herdsmen ; hippopotami wallowed in a pool near what is now Church Square, in the centre of Capetown. Parties, sent northward to Saldanha Bay, saw many rhinoceroses, and had to make detours to avoid troops of elephants. In this Bay, van Riebeeck's men found a cache of "seal" skins, stored there by the captain of a French ship ; over two thousand seven hundred of the skins were still in excellent condition, though many had been spoilt by exposure. In the following year, another French ship sailed with a cargo of 48,000 skins of sea-lions and many casks of oil. At times, Table Bay seemed to be filled with whales.

With the settlement of the country came the destruction of the wild fauna or its retirement to still undisturbed areas. Game laws were passed, but were difficult, or impossible, to enforce in a country with such widely scattered settlements, and in district after district the wild life was wiped out.

Naturally, game is now most scarce where the cultural advance has been greatest. Some of the finest gifts Nature has bestowed on South Africa in so lavish a fashion, are now extinct. Six of them can never be

replaced; these are the Bloubok (*Egocerus leucophaeus*), the Quagga (*Hippotigris quagga quagga*), the Namaqualand Giraffe (*Giraffa camelopardalis capensis*), the Orange River Buffalo (*Syncerus caffer gariepensis*), the Black-maned Cape Lion (*Leo leo melanochoetus*) and the Red Hartebeest (*Alcelaphus caama caama*) of the south-western Cape Province.

At least eighteen of the larger game animals are rapidly becoming more scarce and would be threatened with extinction in South Africa, if suitable provisions had not been made on their behalf. These are the Knysna and Addo-bush Elephants, South African White Rhinoceros, Black Rhinoceros, Mountain Zebra, Gemsbok, Red Hartebeest, Nyala, Red Natal Duiker, Livingstone Antelope, Oribi, Klipspringer, Vaal Rhebok, Grysbok, White-tailed Gnu, Blesbok and Bontebok. The last three are at present only found on private or fenced lands. In the Cape Province, the Kudu, Rooi Rhebok and even the Springbok are growing rarer from year to year.

South Africa possesses a marvellous array of magnificent creatures, and the great efforts which are being made for their preservation is a tribute to the high standards of civilization maintained in this country. Africa has been the greatest modern stadium for free roaming, grazing and browsing animals. Of nearly 200 different kinds of African Antelopes, the South claims about sixty as its heritage.

As early as 1898, Paul Kruger, President of the Transvaal Republic, set aside the nucleus of that sanctuary which now bears his name, the Kruger National Park. Kruger realized that the only way in which complete extermination of game in South Africa could be avoided, was by means of actual sanctuaries.

There is a strong movement on foot, headed by the Wild Life Protection Society of South Africa, to create national sanctuaries for all animals threatened with extinction ; this is likely to receive the support of the Government, whenever possible.

If the preservation of wild life is carried to a successful conclusion, the Union will remain the richest country in the world in a faunistic sense, and its flora will, incidentally, receive extended ranges free from disturbance.

The Kruger National Park.—The beauty and fascination of the greatest of all Reserves lies in its romantic scenery and remarkable sights. Here the characteristic fauna can be admired in its pristine glory. Large herds of game, and a variety of other animals, arouse the admiration of visitors. The lowveld, with its scattered bushes, trees, euphorbias, aloes and other interesting flora, has a charm of its own, and the magnificent kopjes, palm-fringed rivers, waving reed beds, boulder-trimmed gorges and wide spaces offer a sanctuary to wild life.

At present, it is the only national park in South Africa, and was sanctioned by Parliament in 1926. It is situated in the north-eastern Transvaal, and extends from the Crocodile River near Komatipoort in the south, to the Pafuri River in the north ; the Lebombo Mountains along the Portuguese East African border form the eastern frontier. Its area is 5,002,235 acres or 7,816 square miles. Its greatest length is 220 miles, and its width averages about 40 miles. The park is the home of Elephants, Black Rhinoceroses, Giraffes, Hippopotami, Buffaloes, Lions, Leopards, Cheetahs, Hunting Dogs, Baboons and other game, in all more than 250,000 head of large mammals. Zebra, Blue Wildebeest, Waterbuck, Sable, Sassaby, and Impala are very numerous in the southern portion. Bird-life in the Reserve is also very interesting.

The best season for a visit is from the middle of April to the middle of September, as the climate is then delightfully exhilarating; the Park can be reached within 14 hours by railway from Johannesburg. Permits to visit the Park, and information regarding formalities to be observed, may be obtained from the Secretary, National Park Board of Trustees, 159 Pretorius Street, (Telegrams: "Natpark"), Pretoria.

Pretoria Townlands and Groenkloof Reserves.—Only Oribi, Steenbok, Duiker and smaller animals occur in these relatively small areas.

These are the only Reserves in the Transvaal Province.

The Bredasdorp Bontebok Reserve. — The Union has benefited by the keen interest of Alexander van der Byl and of the Albertyn family in the Bontebok. Indeed, were it not for the generosity of David Albertyn and Pieter Albertyn, this rarest of all the Antelopes in the world would by now have met with the same fate as the Bloubok and the true Quagga, and become extinct.

The Bontebok (*Damiliscus pygargus*) is a small, but most beautiful and richly coloured representative of the widely distributed Hartebeest family. It attains a shoulder height of about 3 feet 3 inches, and its horns are rarely over 16 inches. It is the southernmost representative, and the only indigenous, large mammal in the South Western Cape. Known formerly in large numbers, the last 300 were driven in 1864 into the farm Nachtwacht by their original protector. At one time they increased to 500, but in 1927 only 77 were left on three farms in the Bredasdorp District, and 44 on four farms in the neighbourhood of Swellendam.

In olden times, Bonteboks roamed over the richest pastures from south of the Langebergen to the Strand Veld along the Cape Agulhas region and eastward to the coast.

The Gordonia Reserve.—North of Upington, in the Gordonia Division, lies a tract of arid, waterless country 3,400 square miles in extent, which serves as a refuge for that peculiar portion of the fauna that feeds on succulents and xerophytic vegetation. In what might appear to many a desolate waste, they thrive astonishingly well. The Gemsbok, Red Hartebeest, Blue Wildebeest, Springbok and Ostrich are the most important among the wild creatures.

Though perfectly harmless, no more vigorous opponent can be found in self-defence than the handsome and impressive Gemsbok (*Oryx gazella gazella*). With their long spear-like horns they challenge even the boldest lion. Extraordinarily frugal in habits, they flourish in desert wastes where they dig out with their hoofs the succulent roots of various plants. Their striking appearance enlivens the barren solitudes. The spirited and concordant action of their well proportioned bodies, as these Antelopes try to pass at top speed in front of approaching motor-cars, is an entrancing sight.

Knysna Elephants in Forest Reservation.—Only about a dozen Elephants are left of herds that were estimated at four to five hundred strong in 1876. Their favourite haunts are at Deepwalls, Gauna and Buffels Nek, about 10 to 20 miles from Knysna. These Elephants (*Loxodonta africana toxotis*) belong to the south-western race and live in the area of the finest primeval forests still in existence in the Union.

The Addo-bush Reserve.—About thirty miles north of Port Elizabeth, about 8,000 acres of dense, shadeless scrub, are now reserved for a troop of about 25 Elephants, some Buffaloes, Kudus, Bush-buck and small game.

The setting aside of a suitable water supply in the sanctuary assisted much in preventing the Elephants and other game from invading the lands of neighbouring settlers. The profusion of suitable food plants makes the

Addo-bush a real paradise for the Elephants. The branchlets of acacias, the nutritious and succulent leaflets of the Spekboom (*Portulacaria*), various aloes, and tall cotyledons are as characteristic as thickets of Euphorbias. This Reserve is a particularly valuable asset, and in years to come it should form a great attraction.

Mountain Zebra Reserve.—Sir Lionel Phillips has suggested that troops of Mountain Zebras (*Hippotigris zebra zebra*) should be established on the slopes of Bain's Kloof. These Zebras are the pride of South Africa, being by far the largest mammals in the world adapted to a life in the mountains. They are unique among the horse family in having established their homes where otherwise only members of the sheep and goat families flourish. Some still eke out a meagre existence on the bleak, stony wastes of a few farms near Cradock, and south of Oudtshoorn.

The Sommerville Reserve.—This is the only official Reserve in the Orange Free State and is situated in the District of Winburg. It comprises 24,073 acres and contains about 4,000 Blesbok and 2,000 Springbok, to which Black Wildebeest and Red Hartebeest are soon to be added.

In such restricted areas, as also in all privately-owned Reserves, the elimination of surplus game, at certain periods, becomes a necessity. 400 Blesbok and 40 Springbok were shot in this Reserve in 1927. Chiefly old rams and ewes are removed, as determined by a previous census.

The Umfolozi Reserve.—The area of about 75,000 acres contained in the triangular zone between the Black and White Umfolozi Rivers in Zululand, Natal, was formerly a reserve, but nine years ago, game protection in this district was withdrawn. Great attention is focused upon it as it contains the last troops of the nearly extinct South African White Rhinoceros (*Ceratotherium*

simum simum). About twenty of these rare mammals, form a unique treasure among the gigantic fauna surviving from bygone ages. The park lies amid charming scenery, easily accessible by rail and motor car. Besides the White Rhinoceroses, one may observe a few Black Rhinoceroses and fair troops of Buffalo, Zebra, Blue Wildebeest, Kudu, Waterbuck and Reedbuck, while Rooi Rhebok, Bushbuck, Duiker, Klipspringer, Warthog, Bushpig, Aardvark, Giant Pangolin, Dassy, Spotted and Brown Hyaena have also been recorded.

Unfortunately most of the Zululand Reserves lie in a country infested by Tsetse fly, chiefly *Glossina pallidipes*. Here Nagana, a trypanosome disease fatal to domestic stock, prevails.

The Hluhluwe Reserve.—This is perhaps the most remarkable of all areas for the protection of game in the Union. Over a hundred Black Rhinoceroses are to be found on the hills, between which the headwaters of several streams meander. This unfenced and practically unguarded Provincial Reserve of over 40,000 acres, is situated north of the Umfolozi Reserve. Much other game enjoys the protection of this refuge.

During several decades such Rhinoceroses as were chased out by their stronger competitors or possessed of too strong an incentive to wander afield, naturally forfeited their lives, as soon as they were outside the sanctuary. Those now in the Reserve do not show the usual aggressiveness for which this species is so well known. By using proper precautions they can be observed without the danger of being charged, and thus are a unique asset.

The Mkusi Reserve.—Further north in Zululand, 62,000 acres of bush country are set aside as a Provincial Reserve, mainly for about 250 of the rare Nyala. Some of the rarer small Antelopes such as Sharpe's Steinbuck

and the Zululand Suni occur within the Union only in this Reserve. This is also the southernmost point for Lions in Zululand.

The Ndumu Reserve.—The northernmost and most charming Reserve in Zululand extends over 24,320 acres. On account of its tropical haunts, it has a strong appeal for those delighting in a variety of wild life. The Nyala, Impala and Hippopotamus are the principal game animals. Bordering on the Maputu, it includes half a dozen pans, and is traversed by the lower Pongola River.

The Dukuduku or St. Lucia Reserve.—This Forest Reserve comprises about 4,300 acres, and contains characteristic and picturesque tracts of the palmveld (*Hyphaene crinita*). Hippopotami and Water Birds are chiefly protected, and it is the only Reserve in Zululand that contains no Tsetse fly.

The Giants Castle Reserve.—Imposing mountain scenery over about 30,000 acres make this Reserve one of the most attractive in the Union. It can be reached by motor-car from Pietermaritzburg or Howick. From 500 to 600 of the typical South African Eland own here a park at an altitude of over 6,500 feet. Not far from it lies the Forest Reserve of Cathkin Peak, where Eland have also found a home. Besides many smaller animals this magnificent park also contains Rooi-Rhebok, Vaal Rhebok, Oribi and Klipspringer. Its delightful valleys and fine vistas make this an attractive Reserve.

"Seal" and Bird Islands under Government Protection.—At least 37 islands, scattered along the southern and western coasts, are inhabited by spectacular colonies of birds and Sea-lions. From near Port Elizabeth, they extend westward and northward to the coast of Damaraland, where Cape Cross, with its immense herd of Sea-lions is also included.

Plate 30.]

BONTEBOK.

(*Damaliscus pygargus.*)

Some of the islands furnish annually about 9,000 tons of Guano and 10,000 skins of Sea-lions. On account of this valuable fertilizer and the " Cape fur seal skins", the islands are under the charge of the " Superintendent of Guano Islands", who is stationed at Capetown, and is authorized to issue permits to visitors. Boats call regularly at the most important islands, to land provisions for the guardians and their personnel.

As Guano-producers, the young of the three following birds are particularly important : the Cape Cormorant or Trek Duiker (*Phalacrocorax capensis*), the Cape Gannet (*Moris capensis*) and the Cape Penguin (*Spheniscus demersus*), but a great number of other birds are either resident on, or visit, the islands. Among these visitors, the flocks of Flamingoes and Pelicans of Ichaboe Island are noteworthy.

Dassen Island, and the islands in the neighbourhood of Saldanha Bay, are the most accessible.

The colonies of Sea-lions (*Arctocephalus pusillus*) can best be studied at Seal Island in False Bay or at Geyser Island near Dyers Island on the Bredasdorp coast ; but the more northern Hallamsbird Island is, perhaps, the most interesting.

Private Game Farms.—The most important establishments of this type are in the Orange Free State, where they are managed on an economic basis. Black Wildebeeste, Blesbok and Springbok are species thus favoured. These farms generally exceed 2,000 morgen, and are mostly situated in the Kroonstad, Hoopstad, Winburg and Bloemfontein Districts. The private intervention of these farmers saved, at a most critical period, Black Wildebeest and Blesbok from extinction.

In the Cape Province, the Springbok, Kudu and Blesbok are kept by a few of the more wealthy farmers. On Potteberg, Bredasdorp District, some hybrids of

Bontebok and Blesbok appear to do well. Near Kimberley, the De Beers Consolidated Mines keeps Black Wildebeeste, Red Hartebeeste, Springbok and Veld Zebras. A number of fenced farms in the Transvaal contain Blesbok, Springbok, Kudu and smaller game. These are, as a rule, less firmly established than similar areas in the Orange Free State. Much game in a wild state is still found along the Limpopo and Olifants Rivers.

XIII.

ASTRONOMY IN SOUTH AFRICA.

By H. E. WOOD, M.Sc., F.R.A.S., Union Astronomer.

The following table, compiled from the Nautical Almanacs of 1905 and 1929, shows the geographical distribution, according to zones of latitude, of the astronomical observatories of the world.

Latitude.	1905.		1929.	
	North.	South.	North.	South.
90°—80° ..	—	—	—	—
80°—70° ..	—	—	—	—
70°—60°	1	—	1	—
60°—50° ..	54	—	82	—
50°—40° ..	56	1	105	2
40°—30° ..	15	9	45	15
30°—20° ..	1	4	2	11
20°—10° ..	4	—	9	3
10°— 0° ..	—	—	3	1
	131	14	247	32

The great disparity between the number of observatories in high northern latitudes and the number in the rest of the world still exists, but since 1905 there has been a considerable improvement as regards the southern hemisphere, and this improvement is largely accounted for by the increase in the number of observatories in

South Africa. In 1905, 2 out of the 14 listed southern observatories were in South Africa ; in 1929, 9 of the 32 southern observatories figuring in the Nautical Almanac list, are in South Africa, and since the preparation of that list, another very important addition has been made to the number of observatories in South Africa.

There is a remarkable difference between the state of astronomy in South Africa at the time of the previous visit of the British Association in 1905 and its present condition. When the late Sir David Gill, His Majesty's Astronomer at the Cape, 1879-1907, wrote a report on "Astronomy and Geodesy in South Africa" for the volume "Science in South Africa," a handbook on scientific work in South Africa, prepared on the occasion of the visit of the British Association to South Africa in 1905, his remarks were confined almost entirely to the activities of the Royal Observatory.

In reviewing the present state of astronomy in South Africa, we have to consider the work of no less than five large observatories, viz., the Royal Observatory, the Union Observatory, the Yale Southern Station at Johannesburg, the Lamont-Hussey Observatory at Bloemfontein and the Boyden Southern Station of Harvard Observatory at Mazelspoort, Bloemfontein. This great increase in the number of observatories within the Union of South Africa demands a few words of explanation, for it is a most remarkable event in the history of astronomy.

It will be obvious that a fairly young country such as South Africa could not be expected to support such a large number of observatories. As Sir David Gill pointed out in 1905 "When the struggle for life is keen, men do not stop to investigate scientific principles for themselves, and have only time to borrow the results of scientific discovery by others for their own immediate ends. This has hitherto been the case in South Africa." As with men, so with countries ; the serious practical problems

Plate 31.] THE SOUTHERN CROSS.

1910, June 11. *130 minutes' exposure.*

which a young country has to face must necessarily receive attention before the claims of pure scientific research can be considered. Nevertheless, the Government of the Union of South Africa has always recognized the importance of astronomical research, and, in founding and maintaining the Union Observatory at Johannesburg, has done, when revenue and population are taken into account, quite as much as could be expected. This is the only observatory in the Union maintained by the Government. It came into existence officially on 1st May, 1912, and was one of the many concrete results of the welding together of the four Provinces of South Africa. Formerly, there had been the Transvaal Observatory, chiefly charged with the development of the meteorological services of the Province, and the Natal Observatory at Durban, partly an astronomical observatory and partly a meteorological department. The unification of the provinces afforded the opportunity of amalgamating four provincial meteorological services, and of creating a central meteorological department with headquarters in Pretoria. The astronomical observatories were thus relieved of the heavy burden of managing a meteorological service, and were free to develop as purely astronomical institutions. In view, however, of the fact that the climatic conditions as affecting astronomical research were so far superior on the high veld to the conditions prevailing at Durban, it was decided to concentrate at Johannesburg, and equip a large observatory there rather than maintain two smaller observatories, one of which would be handicapped by unfavourable atmospheric conditions.

The Royal Observatory of the Cape of Good Hope has been on South African soil for well over one hundred years. It was established by an Order-in-Council of George IV. of 20th October, 1820. The first of His Majesty's Astronomers at the Cape arrived there on 12th August, 1821, and the site of the Observatory was decided

upon in 1822. From its inception, the maintenance of the Royal Observatory has been met from the ordinary estimate of the British Navy, and the Observatory is still under the control of the British Admiralty.

The remaining observatories established in South Africa are all Southern Stations of old-established observatories of the United States of America. Yale University Observatory has established a southern station, equipped with a 26-inch photographic refractor, at Milner Park, Johannesburg; the Astronomical Department of the University of Michigan has been enabled, through the generosity of one of its former students, to erect a 27-inch visual refractor on Naval Hill, Bloemfontein, and to send out a staff of three astronomers to carry on a survey of the southern sky for double stars. The Harvard Observatory of Cambridge, Massachusetts, which has maintained a southern station at Arequipa in Peru since 1889, has now decided to move this station to Mazelspoort, near Bloemfontein. It may also be mentioned here that the Smithsonian Institution of Washington, seeking a site for a solar observatory, where there would be a reasonable chance of making almost uninterrupted observations of solar radiation, finally equipped its station at Mt. Brukkaros in South-West Africa.

South Africa has thus become the home of a number of branches of the older northern observatories, but the reason for their adoption of South Africa is not entirely on account of the very favourable climatic conditions prevailing here. It is also due to the welcome which has always been extended to astronomers from other parts of the world, who have, on many occasions, been invited here to take part in special investigations. Sir David Gill, impressed with the tremendous amount of work to be done in the southern hemisphere, and the inadequacy of the southern observatories and their staffs to deal with urgent problems, seized every opportunity of inviting

northern astronomers to visit South Africa, and to assist in extending knowledge of the southern section of the universe. In 1879, after he had been appointed His Majesty's Astronomer at the Cape, but before he had taken up residence there, he met Mr. W. L. Elkin, then a student at Strassburg. Mr. Elkin had just completed a dissertation on the orbit and parallax of Alpha Centauri, and asked Gill to supply him with observations of the Star. The result of the meeting was that Gill invited Elkin to the Cape to assist in the determination of the parallaxes of bright southern stars, and Elkin spent two years at the Royal Observatory before leaving it to carry on similar work at Yale Observatory. Professor Auwers, of Berlin, visited the Cape in 1889, and assisted Gill in the programme of observations of the asteroid Victoria for the determination of the solar parallax. On 18th January, 1890, the U.S.S. " Pensacola," with the American eclipse expedition under Professor D. P. Todd, called at Cape Town when returning from Loanda after the total eclipse of 22nd December, 1889 (when a cloudy sky prevented successful observations). One member of the party, Mr. Harold Jacoby, elected to remain at the Royal Observatory for the greater part of the year to study the practical workings of the heliometer. He cemented his association with the Cape by marrying a grand-daughter of Sir Thomas Maclear, H.M. Astronomer at the Cape, 1833—1870.

The list of northern astronomers whom Sir David Gill induced to visit the Cape, might be greatly increased. Dr. de Sitter, now Director of the Leiden Observatory, came into contact with Sir David Gill in the laboratory of Professor Kapteijn at Groningen, in Holland, where de Sitter was then working as a student of astronomy. The result of the meeting was that Dr. de Sitter spent over two years at the Royal Observatory, from August, 1897, to December, 1899. It is thus apparent that many northern astronomers have had personal contact with

South Africa and South African astronomers, and the impressions received by these visiting astronomers have played their part in the decision of so many American observatories to adopt South Africa as their pied-à-terre in the southern hemisphere.

Sir David Gill's policy of urging northern astronomers to come South, where there are so many astronomical problems awaiting and inviting solution, has been energetically continued by Dr. R. T. A. Innes at the Union Observatory, Johannesburg. The policy has been officially sanctioned by the Union Government, and an agreement has been made with the Leiden Observatory in Holland, under which astronomers from Leiden shall have every facility to visit Johannesburg, and " to use the instrumental equipment of the Union Observatory for the purpose of extending to the southern sky the researches they have been making over the northern."

The first Dutch astronomer to visit Johannesburg according to this agreement was Professor E. Hertzsprung, who has just been awarded the Gold Medal of the Royal Astronomical Society. During his visit he made an extensive photographic survey of selected southern regions for the discovery of variable stars and the determination of their light curves. He was followed by Dr. W. H. van den Bos, who took part in the systematic survey of the southern sky for double stars during his stay. He, in turn, was followed by Mr. H. van Gent, who is now in Johannesburg continuing the investigations begun by Professor Hertzsprung.

Professor G. Struve, of the Neubabelsberg Observatory, Berlin, has also spent some months at Johannesburg, using the 26½-inch refractor in making observations of the satellites of Saturn. It may then be said that South Africa is rapidly becoming quite a familiar country to European and American astronomers, and that the opportunities for astronomical research provided by the

clear night skies and tranquil atmospheric conditions usually prevailing over the high veld, are well-known as the result of the personal experiences of visiting astronomers. There have been several expeditions to South Africa with the definite object of testing the astronomical conditions generally prevailing ; these have been made by Professor Solon I. Bailey, of Harvard Observatory, by the late Professor W. J. Hussey, of the University of Michigan Astronomical Department, and by Professor Schlesinger, of Yale Observatory, and their visits have resulted in sites being selected for the South African Stations of their respective observatories.

Enough has been said to indicate that there is now in South Africa a remarkable astronomical equipment, and a sufficient number of astronomers to make such an attack on the southern skies, that in a few years' time our knowledge of the southern half of the stellar universe will be comparable with that of the northern. With so much work awaiting to be done, it is very essential, however, that there should be no wasted efforts, and that, as far as possible, there should be co-operation between the southern observatories to avoid duplication of work. A brief survey of the principal programmes of work carried out at the South African observatories will show that this economy of effort has received due consideration.

The Royal Observatory at Cape Town has an old-established tradition to follow. In the years 1751-1753, the Abbé de la Caille made an extraordinary series of astronomical observations at Cape Town ; in that short period he compiled the material for his catalogue of 10,035 southern stars, and obtained observations of the Moon and the planet Mars, from which, in combination with corresponding observations in the northern hemisphere, he derived the then most reliable values of the lunar and solar parallax. In the course of this short period, he laid the foundations of sidereal astronomy in the southern

hemisphere, and indicated the lines of research which subsequent astronomers at the Cape have followed. The site of La Caille's observatory in Strand Street, Cape Town, is marked by a commemorative tablet on the building which now covers the spot.

The principal task of the Royal Observatory has thus been to produce precision catalogues of the places of the southern stars, and the amount of space occupied on the shelves of an astronomical library by star catalogues issued from the Royal Observatory, shows how assiduously this work has been done. Such work is not an object of much popular interest, but it is the work for which national observatories are really established, and which forms the foundations on which our knowledge of the universe is built up. In addition to the precision catalogues, in which the positions of selected stars are given with the greatest degree of accuracy, there is another class of star catalogue, which is most necessary and important, not only to serve for the identification of stars, but also for the study of the distribution of the stars in space, namely, a catalogue which shall contain all the stars of the sky to a certain degree of brightness with their approximate positions and brightnesses. In the year 1882, a very brilliant comet was visible from the Cape, and several photographers in South Africa obtained photographs of it with their ordinary apparatus. Their results were not of scientific value, because they could not allow for the motion of the earth or of the comet, but the photographs aroused the interest of Sir David Gill, and, with the assistance of a local photographer, much improved results were obtained. As representations of a comet itself, these photographs had great scientific interest, but they conveyed much greater possibilities to Gill. The great number of stars which had left their images on the plates suggested to him the practicability of producing star catalogues, giving all stars down to any degree of faintness, through the agency of photography.

So, from the examination of the photographs of the 1882 comet, there ultimately developed the famous Cape Photographic Durchmusterung, a catalogue giving the positions and brightness of 454,875 stars. In the carrying out of this great work, Professor Kapteijn, of Groningen, co-operated with Sir David Gill, and devoted over twelve years of his life to the task. While this work was in progress, an international scheme of photographing the whole sky on a larger scale and producing a series of catalogues which should give the positions of all stars down to the 11th magnitude and with a higher degree of accuracy, was developed, mainly at the instigation of Sir David Gill. The work was divided amongst a large number of observatories; some of it is not yet finished, but the portion of the work allotted to the Royal Observatory has long been completed, and eleven volumes of the "Cape Astrographic Zones" stand on the astronomer's shelves.

As has already been stated, the Abbé de la Caille, during his stay at the Cape in 1751-53, in addition to forming a star catalogue, made further observations, which resulted in the most accurate determinations at that period of the solar and lunar parallax. Thomas Henderson, the second of His Majesty's Astronomers at the Cape, 1832-1833, was the first, from his observations of Alpha Centauri, to produce reliable evidence of the measurable parallax of any fixed star. It is natural, therefore, that the traditions of the Cape Observatory should also be intimately associated with the great fundamental problem of determining the distance of the sun and then the distances of the stars. Every astronomer at the Cape has taken part in the determination of the sun's distance, and observations made at the Cape Observatory, in conjunction with similar observations made at northern observatories, of the planet Mars and of the minor planets, Victoria, Iris and Sappho, have

steadily led to an increasingly accurate determination of this fundamental astronomical unit.

After Henderson's discovery of the measurable parallax of Alpha Centauri, and the confirmation of his results by his successor, Sir Thomas Maclear, no systematic effort was made to add to our knowledge of the distances of southern stars until 1879, when Gill, aided by Elkin and later by de Sitter, determined the distances of a number of the brightest southern stars. These determinations were made by visual observations ; it has now been established that the distance of a star can be determined much more accurately and with less expenditure of effort by the aid of photography, and the present Astronomer at the Cape, Dr. Spencer Jones, is determining stellar parallaxes from photographs taken with the 24-inch Victoria Telescope.

The Union Observatory, an institution which may almost be said to have come into existence as the result of the first visit of the British Association to South Africa in 1905, has a very short history, but its main activities are already well defined. The first Union Astronomer, Dr. R. T. A. Innes, was well known to astronomers as an amateur devoted to the discovery and observation of double stars long before he became an official astronomer. In 1897, he joined the staff of the Cape Observatory, and, although it formed no part of his official duties at the Observatory, he prepared the " Reference Catalogue of Southern Double Stars," in addition to making large numbers of discoveries of new double stars and long series of measurements of known double stars.

In 1903, Dr. Innes was appointed to take charge of the new Transvaal Observatory, and continued to make discoveries and measurements of double stars, although his duties were then mainly concerned with the organization of a meteorological service for the Province. In 1909, a large refracting telescope of 26 inches aperture,

Plate 32.] HALLEY'S COMET.

38 minutes' exposure.

1910, May 14.

with object glass and equatorial mounting by Sir Howard Grubb, and a filar micrometer by Repsold, of Hamburg, was ordered for the Observatory so that the survey of the southern skies for double stars might be carried out under the best possible conditions. Owing to unexpected delays, this large telescope was not placed in commission until 1925, but since that time it has been in continuous use for the work of the double star survey. At the end of 1927, a "New Southern Double Star Catalogue" was issued from the Observatory, including about 8,000 stars, comprising every known double star south of $-19°$. The Union Observatory is now looked upon as a central office for all matters relating to double star astronomy in the Southern Hemisphere, and the development of this branch of astronomy will always be one of the principal activities of the observatory.

In 1909, the 10-inch photographic telescope which is now well-known as the Franklin-Adams Star Camera, was presented to the Transvaal Observatory by the late Mr. J. Franklin-Adams. Mr. Franklin-Adams was a very successful business man and an enthusiastic astronomer. He cherished the design of charting the whole heavens, both north and south, photographically, and for this purpose he procured from Messrs. T. Cooke and Sons, of York, England, a well-designed equatorial mounting of the English type, driven by a Repsold clock and carrying two Cooke triple photographic lenses of 6 inches and 10 inches diameter. This instrument was mounted in the grounds of the Royal Observatory at Cape Town in 1902, and the southern sky was charted. It was then re-erected at Mr. Franklin-Adams' residence in England, and the northern sky was photographed there. Finding that the northern plates were of better quality than the earlier southern ones, Mr. Franklin-Adams decided to return to South Africa and repeat the work done there. Illness interfered with his plans, and, not being able to make the journey to South Africa himself, he presented the telescope

to the Transvaal Observatory on the understanding that the work of completing his charts would be the first work to be carried out with the instrument.

Mr. Franklin-Adams did not live to see the full outcome of his work, as he died in 1912. It was arranged that the original chart plates should be stored at Greenwich Observatory, where they have already served as the material for several investigations into the structure of the stellar universe. The Royal Astronomical Society has published copies of the photographs.

With its large field and powerful light grasp, the Franklin-Adams Star Camera is exceptionally well adapted for the photography of faint moving objects, such as minor planets and comets, and especially so when it is used in conjunction with the Blink Microscope. Dr. R. T. A. Innes was one of the first to recognise the value of the Blink method in its application to the discovery of variable stars, minor planets and proper motion stars. He secured a Blink microscope from Zeiss at a time when only very few of such instruments were in use at astronomical observatories. If two plates of the same region of the sky have been taken with the same telescope, and preferably under the same conditions as regards length of exposure, then the examination of such a pair of plates with this instrument will reveal the minutest difference between the two plates, whether it be in the position of a star or in its brightness. If the two photographs have been taken at an interval of many years, the motion of the stars themselves may be detected. During the examination of two plates of the region near Alpha Centauri taken with the Franklin-Adams Star Camera in 1910 and 1915 respectively, Dr. Innes detected a faint star, the motion of which was quite noticeable in this rather short interval of five years. Measurement showed that the motion of this star was very similar to that of the double star Alpha Centauri, and it seemed very probable that this

star was also a member of the Alpha Centauri system and was, therefore, one of our near stellar neighbours. The distance of this star has now been accurately determined, with the result that it has been found to be the nearest of the stars, so that the name "Proxima Centauri," suggested for the star by Dr. Innes, has been well justified.

Stars, whose light varies with time, whether periodically or irregularly, are easily discovered by the examination of pairs of plates with the Blink microscope. Professor Hertzsprung and Mr. van Gent, of the Leiden Observatory, have added greatly to the knowledge of southern variable stars by using the Franklin-Adams Star Camera and the Blink microscope for this purpose.

Between the orbits of the planets Mars and Jupiter there is the host of small bodies, known as the asteroids or minor planets. Before 1801, nothing was known to exist in the wide gap between these two planets, although there was a very strong impression that there must be a missing planet in this space. In 1800, an association of observers was formed with the express object of searching the zodiac for undiscovered planets, and on January 1st, 1801, the Sicilian astronomer, Piazzi, discovered the small planet Ceres. The number of planets now known in this region is roughly 1,200. The observation of these small and faint bodies is very easily carried out with the Franklin-Adams Star Camera. Two photographs of a zodiacal region of the sky, with an exposure of about 30 minutes each, are taken immediately after one another. Any minor planet there may be within this region will, on account of its motion, produce its image in slightly different positions on the two plates, and so will be rendered conspicuous in the Blink microscope examination. As the minor planets are in opposition south of the equator of the sky from March to September, and as many of them come sufficiently far south in the heavens to be beyond the reach of northern observatories, the

Union Observatory is frequently requested to obtain observations of these bodies.

Long series of observations of the eclipses of the satellites of Jupiter have been made at the Union Observatory, and the investigation of these led Dr. Innes to the conclusion that the rotation of the earth is not so regular as it has generally been accepted to be, but that it undergoes sudden and considerable changes in rate. It has been suggested that these changes in the rate of rotation are real, and arise from alteration in the earth's diameter, on account of internal causes and amounting at most to a few feet. A further running check on the timekeeping of the earth is obtained by observing the occultations of stars by the moon, and with this object in view, a regular programme of observation of occultations is carried out at the Union Observatory.

The first of the American Southern Stations to be established in South Africa was that of the Yale University Observatory. During his visit to Johannesburg, in June, 1925, the Prince of Wales formally opened this station. Its equipment consists of a photographic refractor of 26-inches aperture and 36-feet focal length, housed in a very unusual type of astronomical building. The telescope and housing have been designed for the special purpose of determining the distances of the stars by trigonometrical methods. The first results of the work at the Yale Southern Station have been published, and give the parallaxes of a number of southern stars with a degree of accuracy, which, owing to the combination of good observing conditions with well-designed equipment, had hitherto not been attained.

Near Bloemfontein, in the Orange Free State, are the Southern Stations of the University of Michigan Astronomical Department and of Harvard Observatory. The former, known as the Lamont-Hussey Observatory, will confine its activities for a period of eight to ten years

to a programme of discovery and measurement of double stars. Since similar work, and with a telescope of almost the same dimensions, is carried out at the Union Observatory, co-operation between the two observatories was very desirable, and, accordingly, an arrangement has been made, allocating different zones of the heavens for investigation at the two observatories.

The Harvard Southern Station has not yet received its full equipment, which will include a large reflecting telescope 60-inches in diameter and a photographic refractor of 24-inches objective with attachments for stellar spectroscopy. The need for a large reflecting telescope in the southern hemisphere has long been felt, particularly so in connection with the investigation of the remarkable star, Nova Pictoris, which is so far south in the sky as to be quite out of reach of the existing large reflectors. The principal work of the Harvard Station will be the determination, by spectroscopic and other methods, of the distances of stars which are too faint or too distant to be measured by trigonometric methods, and also the investigation of the nature and constitution of the southern stars.

The present time marks the beginning of a new era in astronomy in the southern hemisphere. Hitherto our knowledge of the stellar universe has been somewhat unbalanced, and all statistical investigators have been seriously handicapped in their work by the paucity of data concerning the sky visible from south of the equator. For example, in the catalogue of trigonometric parallaxes issued by Schlesinger, out of 1,682 stars listed in the catalogue, only 205 were south of the equator. The situation is, however, now entirely changed, and, in the course of a few years, the work of the South African observatories will have rendered our knowledge of the southern stars comparable with that of the northern.

No review of astronomical work in South Africa would be complete without recognition of the valuable assistance

provided by enthusiastic amateurs, in whom South Africa has been unusually fortunate. Variable star astronomy owes much to the long-continued work of Dr. Roberts, of Lovedale ; to Mr. Watson, of Beaufort West, fell the discovery of the remarkable star, Nova Pictoris. In the discovery of comets, South African amateurs appear to excel. The late Mr. Reid received the Donohoe Medal, awarded for cometary discoveries, on no less than seven occasions ; other discoveries have been made in recent years by Skjellerup, Blathwayt, Ensor, and within the last few months a remarkably interesting periodic comet has been added to the list by Mr. Forbes, of Cape Town.

XIV.

ANTHROPOLOGY.

By RAYMOND A. DART, M.D., Ch.M., M.Sc.

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The progress that has been made in the Science of Anthropology in the quarter of a century which has intervened since the last visit of the British Association to South Africa, and especially during the latter half of that period, has been phenomenal; to some extent because some aspects of that development have been so unexpected.

The late Dr. L. Peringuey, who may rightly be regarded as the father of South African Anthropology, contributed an important article on "The Stone Age in South Africa" to "Science in South Africa," which was published on the occasion of the visit of the British Association in 1905. In the same volume, Mr. W. Hammond Tooke dealt with "Uncivilised Man South of the Zambesi," and Mr. R. N. Hall wrote on "Rhodesian Antiquities." At that time, beyond the natural scientific interest attaching to those two distinct and strictly African types of humankind, the Bushman and the Negro and their cultures, to the common knowledge of the prevalence of stone implements, rock paintings and etchings and to the riddle of the ancient ruins of Rhodesia, there was little to excite comment or attention.

It was in 1913, with the discovery, near Potchefstroom in the Transvaal, of a new and unknown, bizarre, big-brained, human type, which has hitherto not been retrieved outside of Africa, the so-called Boskop man or

Homo capensis of Broom, that the attention of scientists was first seriously directed to the likelihood that South Africa had played something more than a subsidiary role in the early history of the human race. That probability was greatly increased by the finding of a skull in 1921 at Broken Hill with the most bestial, human muzzle known, and with receding forehead and enormous overhanging eyebrows simulating in these features the gorilla. For the reception of this being whose nearest known human relatives were the extinct Neanderthal race of Europe, the creation of a new species *Homo rhodesiensis*, more primitive even than the Neanderthaler's, has been necessitated. Unfortunately, nothing is yet known of its geological age or its geographical distribution.

It is generally agreed amongst physical anthropologists that *Homo rhodesiensis* (Smith-Woodward) is to be separated from the Neanderthal folk as more bestial and primitive. Whether as a species it is ancestrally so related, is one of the major points upon which we may anticipate that the future recovery of remains will elicit interesting information. But, independently of that particular issue, the fact that Neanderthal remains have now been discovered at Gibraltar, in Malta and in Palestine, the three high-roads between Africa and the Eurasiatic continental mass in Pleistocene times, renders it virtually certain that Africa has still to yield up many treasures of the Neanderthal period, and that Africa itself was the source of this widely spreading, primitive, human stock. There can be no question at the present time that the balance of evidence is highly in favour of Africa as the cradle of Neanderthal man.

With respect to a knowledge of Boskop men, we are in a much more happy condition than with regard to *Homo rhodesiensis*. Between 1923 and 1926 by the unearthing of remains by Mr. Fitzsimons, at Zitzikama, near Port Elizabeth, and by Major T. G. Trevor, at

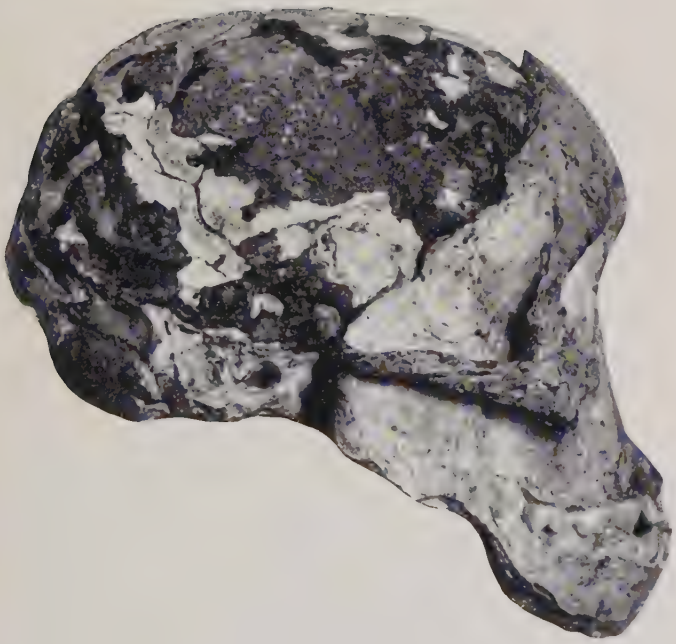

Plate 33.] THE TAUNGS SKULL.

Kalomo in Northern Rhodesia, it was shown that the Boskop type of mankind was a very distinctive one with a widespread distribution in Southern Africa. Mr. H. S. Gear has been able to give us much information concerning the Boskop skeleton and two other points of great importance were established ; firstly, that Boskop man preceded the Bushman because his remains have been found at lower stratigraphical levels than Bush remains at Zitzikama and other sites along the coastal area, and secondly, that the type was not so removed zoologically from the Bush type as to rule out hybridisation between the two races. The most startling evidence in this latter respect came from the occurrence in the dissecting room of the Anatomy Department at Cape Town of a typical Boskopoid skull as announced by Professor Drennan in 1925. Actual Boskopoid hybridisation amongst the Zitzikama material of the higher Bush levels at Zitzikama was demonstrated by Dr. Gordon D. Laing (1925).

Meantime, Dr. Robert Broom, working on the skeletal material in the collection of the Kimberley Museum, revealed the necessity of reckoning also with an Australoid element in the structure of the Bush cranium. The early appearance in the Vaal Valley region and wide distribution of this additional element of racial admixture in South Africa was further explained by H. L. Allen in his description of the fossil Australoid cranium from Mistkraal near Port Elizabeth.

It is apparent from the foregoing that the labours of the intervening period have thrown light on the modern population, not so much by giving us exact anatomical information as to what constitutes a pure Bushman or a pure Negro amongst the Bantu peoples, as by demonstrating how many and how varied a number of racial elements has contributed towards the fabrication of our different ethnic groups. In 1905 it was believed that the native population of South Africa consisted of Bushmen,

Hottentots and Negroes (the Bantu tribes), each anatomically distinct. Investigations carried out in the interim have not, in my opinion, revealed any satisfactory means of separating the Bushmen from the Hottentots physically. Not the least important investigation carried out in this country has been that of Shapiro (1926), who has proved that, despite the dissimilarities that exist between the cultures of the Bushmen as compared with the Hottentots, the two types of culture have more in common than they have in difference, and that basically the two cultures are the same. It is, therefore, most serviceable for the present, from the physical anthropological point of view to regard the Bushman, Hottentot and Strandlooper as members of one and the same racial group, *i.e.*, the Bush race.

Actual historical knowledge and the ordinary facts of geographical distribution of the South African races show that the Bantu were displacing the Bush peoples southwards when the Europeans arrived at the Cape. The period of time represented by the Bushman occupation itself is without question very considerable. At Zitzikama numerous layers, 12 to 18 feet deep, of Bush (Strandlooper) deposits are found before the Boskopoid strata are encountered. The Mistkraal Australoid Bush skull was highly fossilised.

At Zuurberg, two burial grounds were found in the open country, one underlying the other, and the skeletons of even the uppermost or 7 feet layer are infiltrated with mineral matter and bear every evidence of high antiquity. In the Vaal Valley at Longlands, a Bush skull has been found 10 to 12 feet deep in the 60 to 80 feet terrace. While no time estimations have yet been set on record, there can scarcely be any doubt that this period extends back several thousands of years. There is great need in this connection for carefully organized excavation of chosen caves and rock shelters, amongst which those in

the Knysna-Zitzikama and Zuurberg region promise very successful results. Such excavation should be directed particularly to the stratigraphical and chronological aspects which are so poorly understood, and to the description of the accompanying faunal remains.

The Bush race as known to-day is certainly not a pure race. We have already discussed the presence of Australoid and Boskopoid admixture therein. The Southern intrusions of Negroid peoples have left their marks also in the bodies of the modern Bush peoples. Equally throughout all the Bantu tribes Bush types are found, which demonstrate that, within the areas conquered, the Bantu did not wholly exterminate these smaller folk, but intermingled with them. The typical cranial form of the Bush peoples is chamaecephalic, orthognathic and pentagonoid ; in other words, they have a low pentagonal skull with vertical facial profile. The typical cranial form of the South African negro is ortho- or even hypsicephic, prognathic and ovoid or even ellipsoid ; they have high elliptical skulls with projicient facial profile.

But the anatomical riddle of the living South African native peoples is not entirely read when these facts have been unravelled. For a very long period, probably for thousands of years, both the Bantu and Bush peoples, which are both manifestly Negroid stock, and at that racially impure, have been exposed to an extensive admixture with the Caucasoid and Mongoloid branches of the human family, especially on the Eastern Coast. Typical sphaeroidal and eurypentagonoidal, brachycephalic Mongolian skulls appear in a small, though definite, proportion of our skeletal collections. The Mongolian slit eyes and elevated cheek bones amongst the Eastern Division of the Bush-Hottentot group were so patent to the early Dutch Settlers that they called them "Chinese Hottentots." Classical Egyptian heads with

aquiline noses, delicately modelled features set on slender necks, betray admixture with the Brown or Mediterranean group of the Caucasian family. The Arabic and Semitic groups are equally manifest in an amazingly large proportion of almost every South African Bantu tribe, the last named especially amongst the tribes of Rhodesia and the North-eastern Transvaal.

These points illustrate the complexity that has confronted the study of living man in the sub-continent and provide some clues to the extensive amount of anatomical spade-work which remains to be done before we can hope to interpret completely the cultural aspects of South African anthropology and its archaeology.

In 1905, few, if any, scientists anticipated that Africa, and least of all South Africa, had any expectation of contributing to our understanding of that phase of human evolution which wholly antecedes the human phase, however primitive, but links the most primitive human phase with that of the anthropoidal ape. The discovery by Dubois in 1893 in Java of *Pithecanthropus erectus*, the earliest known human type, and the remarkable series of advanced anthropoidal remains unearthed in the Siwalik Hills of India by Pilgrim had led anthropologists to regard the benign tropical or sub-tropical regions of Asia as the cradle of these earliest developmental stages in man's emergence. The recovery of *Australopithecus africanus* at Taungs in Bechuanaland on the eastern fringe of the Kalahari Desert, therefore, not only provided for anthropological examination the most advanced anthropoidal ape hitherto discovered, a form intermediate between the highest living anthropoids on the one hand and the most primitive known human being, *Pithecanthropus*, on the other hand, but it opened up a new vista in regard to the scene and the factors surrounding man's origin. It showed us for the first time a truly man-like ape, an ape living like man away from the tropics and the forest, in a temperate region, in caves looking out over plains, swift of

NEGROID.

SEMITIC.

BAVENDA : Sibasa, Northern Transvaal.

MONGOLOID.

MONGOLOID.

BACA : Kinira, East Griqualand.

Plate 34.] [*From photographs by A. M. Duggan-Cronin, Kimberley.*

foot, dexterous of hand and subsisting on the fruits of capture and the chase. It showed that at the Taungs phase of evolution the wide world was already the spoil of man's ancestors, that mountain, stream, prairie or plain provided no insuperable barrier to their expansive ambition, and Darwin's expectation was justified that Africa, the present home of the highest living forms of anthropoid, had been in all probability the laboratory of man, the supreme product of primate development.

There is a great deal of misconception prevalent on the question of the cradle of the human race owing to the confusion of thought of many writers on this topic. The very vital part which has been played within the recent or historical period by the pressure of the expanding Mongolian, Armenoid and Nordic peoples upon the Brown Race of the Mediterranean Basin, Egypt and Mesopotamia has been so impressive as to turn men's minds instinctively to Asia and the East for the explanation of all human origins. That Asia has been the evolutionary home of the Mongolian branch of the human race few are likely to dispute, for the traces of Mongolian relationship that are found in other continents, including Africa, are apparently to be explained by expansions or excursions from Asia. The Armenoid peoples may also have arisen in Central Asia, just as Europe may have been the centre of Nordic origins ; but the natural home of the Brown and least specialized branch of the Caucasoid stock is in Northern Africa and the Mediterranean Basin. The more primitive Black races or Negro stock comprising the Pygmy, Bush and Bantu, are wholly and characteristically African products, and to their evolution Africa must hold the key. Of stocks more primitive than those now living she has given us an elsewhere unknown human type, Boskop man. The bias of evidence as we have seen indicates Africa, and not Asia, as the centre of the pre-Neanderthal stock, and she, like all other continents,

retains the Australoid influence. Before *Homo rhodesiensis* she demonstrates the sub-human *Australopithecus*, and preserves in her primeval forests to the present day the chimpanzee and gorilla, which, outside of mankind himself, expressed the climax of evolutionary achievement. No other continental land mass can as yet provide so formidable an array of convergent evidence upon the thesis as to where the sub-man first had his being. But, independent of this particular and in some respects academic issue, the advances in anthropological knowledge of the last quarter of a century in South Africa have at least demonstrated one thing, and that is, that however much information may be elicited by the prosecution of anthropological studies in Europe and in Asia, the science cannot fail in being partial, one-sided, incomplete, and generally unsatisfactory in the highest degree, until a similar intensive survey of the whole African continent has been carried out. It appears equally obvious that the approach towards that survey should be through the complete exploitation of the South African area, where so much has already been done. Working on the information already accumulated here, stratigraphical and geographical conclusions, of more than local value to the science, might well be established by a few experts.

Tentative enquiries in these fundamental fields have already been launched. In the hands of Peringuey, Johnson, Neville Jones, Goodwin, Van Riet Lowe, Van Hoepen, Hodkinson, Hewitt, Stapleton, Heese and others, a great fund of knowledge concerning the locality distribution of lithic cultures has been amassed and the time is rapidly coming when accurate maps of their distribution throughout Southern Africa will be available. Progress in this important field has been one of the most striking achievements of the last decade. The results arrived at are now common knowledge through the publication of M. C. Burkitt's " South Africa's past in stone and paint," a very timely contribution to the

clarification of garnered data and a noteworthy point of departure for all future enquiry in cultural anthropology, and through the recent monograph on "The stone cultures of South Africa," published by Goodwin and Lowe in the Annals of the South African Museum (Vol. XXVI, 1928), in which a complete bibliography is given.

The publication by Miss Helen Tongue of a valuable series of Bushman paintings extended considerably what had been advanced through the classical work of Stow on the races of South Africa. To all those interested in this department of knowledge, the information that the Carnegie Foundation has devoted £2,000 recently to the work of publishing the valuable collections of paintings collected by Miss Bleek and by Bro. Otto is most welcome. In the meantime it has been fairly satisfactorily established that there are the strongest affinities between South African palaeolithic art and that described in Spain and North Africa as Capsian. Much remains to be done in determining the exact relationship between the two, in isolating the different age phases of the work, in localising the centres of its evolution and the lines of its dispersal, and in discovering to what extent alien influences had been at work in the development of mural art in the country. The same type of enquiry confronts the equally abstruse problem of the stone etchings.

The illustration of the Bushman painting is from a tracing made by Miss M. Wilman. The painting, which is in faded haematite-red and white, is on a rock-shelter at Waterfall, Ficksburg, Orange Free State, and depicts a group of antelopes, isolated antelopes, hares and hunters (one naked and the other clothed and armed). The illustration of the Bushman engraving is from a rubbing by Miss Wilman. The engraving, which is at Van Aswegen's Hoek, Kimberley Division, is of a black rhinoceros; it measures 13 inches from the tip of the horn to the tip of

the tail. The outlines and ribs are furrowed; the rest of the surface is lightly pecked.

No attempt will be made here to discuss in any further detail what has already been thoroughly discussed in Burkitt's work. The major conclusions now arrived at are that South Africa has passed through well-defined Old Stone Age, Middle Stone Age and Recent Stone Age periods. A highly desirable practice has been instituted of labelling the different stone cultural phases of each of these periods with local names to avoid the confusions which would naturally arise by too early an attempt to equate each of the phases with similar European phases. As yet very little is known concerning what human types are associated with, and were responsible for, the many different stone industries. In most instances, the discoveries of human remains have been dissociated from the discoveries of lithic cultures and the most pressing need of the present situation is the discovery and suitable description of sites where human skeletons and implements are unmistakeably associated. Such a site has been excavated with considerable care by Mr. Peers and his son at Fish Hoek near Cape Town with great success. Both Boskopoid and Bush types have been recovered, the latter superimposed on the former and each associated with a characteristic and different lithic culture. That site should form the subject of monographic treatment, and in that case would form a classical point of departure for chronological sequence along the whole of the south-eastern coast line. The recent discovery by Captain Bishop Brown, at Springbok Flats in the Transvaal, of human remains in association with the extinct *Bubalis baini*, has also added to our chronological knowledge of man's antiquity in South Africa.

Another fruitful field of investigation has opened up in the Vaal River gravel terrace. Of these, three are in existence, the highest and oldest of which, 200 to 300

RHODESIAN MAN. BOSKOP MAN.

BUSH MAN. NEGRO.

AFRICAN TYPES OF MANKIND.

Plate 35.]

feet above the river bed, has hitherto yielded no fossils or human implements. The middle terrace 60 to 80 feet above the river bed and the lowest terrace, which actually is found in or near the bed itself, have revealed thousands of implements and numerous fossils. Thus, the middle terrace has yielded up evidence of a Pliocene mastodon and a Pliocene form of mammoth, while the lowest terrace has provided several advanced mammoths associated with a Vaal variant of the Stellenbosch, or very early Old Stone, Age implement culture. These discoveries were of importance, not only because of the high antiquity revealed for the human types which are still unknown and were responsible for this ancient culture, but also because they proved for the first time that members of the mammoth group had existed far south of the equator in the Old World. Geologically, too, they are of great significance, because they have shown that even the lowest and most recent gravel terrace is of considerable antiquity, whereas previously this gravel was looked upon as of no great age.

My initial work dealing with the mammoths at Bloemhof has been followed up most successfully by Mr. Van Riet Lowe on the stratigraphical and cultural side. He has been able to demonstrate for the first time a regular Old, Middle and Recent Stone Age stratigraphical and cultural succession in the river bed and bank, and to prove conclusively that the mammoths belonged to the lowest or Old Stone Age stratum. His investigations have been of considerable importance for this country of unstable water courses and gravel beds, because they have shown that whatever may be the case in other river valleys in South Africa, the Vaal River gravels and terraces have been, and are, relatively stable. These findings have paved the way for the extensive research which is now called for throughout the whole Vaal Valley, more especially as it was in this watershed that both Boskop man and the Taungs skull were first

discovered. The probabilities are now enormously enhanced for the coming to light of a succession of fossils, and conceivably of human types, which will illuminate the whole of early human and pre-human history. Such investigations will not only shed light on anthropological matters, but will continue, as they have done in the past, to add new proboscideans, hippopotami, pigs, horses, giraffes and other mammals to the sum of zoological and palaeontological knowledge, and assist us in the understanding of the evolutionary history of all our present fauna; incidentally they will illuminate the Pliocene-Pleistocene geology of the whole of South Africa which at present is so imperfectly understood.

Turning from the anatomical, lithic and palaeontological aspects of anthropology, it will be of interest to consider what progress has been achieved in other and more recent aspects of the science. One of the most controversial, and least analysed, subjects of archaeology has been that of the Rhodesian ruins and gold mining. The earliest workers like March, Bent and Hall, led by considerable evidence on the architectural and general cultural side, believed them to be non-Bantu and equated these ruins with those of South-eastern Himyaritic and Sabaean or Pre-Koranic Arabia. Their theories received a severe shock at the hands of Randall MacIver in 1905, who, after a few weeks' examination of the territory, delivered a categorical negative to these pretensions by calling the ruins mediaeval and Bantu. Recent investigators of the ruins believe that these cannot be of high antiquity on account of their present unstable structure and ruined appearance, which is tantamount to declaring that the sun-dried brick structures of Mesopotamia are not ancient for similar reasons. The fact remains that certain of these stone buildings are conceived on architectural lines not known to be characteristic of any Bantu race. They are decorated with monoliths, and are designed for phallic worship and, moreover, are provided

with a system of drainage. The ruins are associated with widely-distributed mining activity in gold and other metals and, at Inyanga, with an enormous area planned for terraced irrigation, where numerous plants, not indigenous to South Africa, but to Arabia and India, are still found. Historical evidence exists that China traded extensively with Sofala about the time of the Norman Conquest of England. In the first century, the writer of the Periplus wandered down the east coast of Africa to Zanzibar. The persistence of alien Caucasian and Mongolian admixture with the modern population has already been discussed. It has generally been believed from anatomical, linguistic and cultural evidence that Madagascar has been largely peopled by peoples of South-eastern Asia.

These facts in themselves are sufficient to demonstrate that the Bantu hypothesis of extensive gold-getting and temple-building is untenable, but considerable light has been thrown on the whole mining, agricultural and stone-building complex by a relatively recent series of impressive discoveries. In the first place Trevor, Baumann, Woodburn and others have extended our knowledge of the metallurgical activities of these people by showing that the Rhodesian gold mining centre is surrounded by a far more extensive ring of copper, tin, micaceous iron and ochre mines. Most recently of all, Dr. Percy A. Wagner has shown that bronze was intentionally produced on a site of numerous furnaces on the farm Blaauwbank in the Rooiberg District.

The enormous area of the continent covered by the operations, the extensive scale of the mining in all these minerals and the highly intricate knowledge of metallurgy displayed in the production of bronze, lift the whole problem out of the realm of Bantu fancy, and have demonstrated that the Ancient mining industry constitutes a veritable *Bronze Age* in Southern Africa previous

to and, as far as we know, unrelated to the Iron Age, represented by the Bantu civilization. Even the destination of the bronze may yet be learned. On the farm Blaauwbank, nickel simulating copper is found in abundance, and it appears that the ancients accidentally mixed it with their bronze. This unusual impurity so far as bronze is concerned, crops up, as Prof. Sebelien and Prof. Desch have recently shown, with a remarkable regularity, and sometimes in great amount, amongst the ancient bronze objects of the Egyptian and Sumerian civilizations, while only very rarely and infrequently are traces of nickel found as impurities in the copper mines of the Near East. Many thousands of tons of copper and tin, gold and other minerals, taken from South African soil in the past, are now no longer to be found either in their natural or manufactured form in South Africa, and the presumption is instinctive and incontrovertible that these materials, won at so great pain and suffering from the centre of the continent, were removed, some of it during the Bronze Age of these past civilizations, to the Near East or to more distant regions where it had a commercial value.

Information concerning the homelands of these problematical peoples is forthcoming, not only from the racial admixtures now traceable in the native population of Southern Africa, but also from the actual paintings left behind by Bush people and possibly by their visitors in the rock shelters of the Kei River Valley, Natal and Rhodesia. These paintings, showing strangers in non-European garb, are inexplicable on any other hypothesis. They show cloaked forms in headgear of Babylonian, Phrygian and Chinese design bearing spears, swords and bows and arrows. They depict scenes of rape and capture ; they are moving, emotional, historical records which we owe to the genius of Bro. Otto, who has rescued them from oblivion.

We cannot say that the enigma of Zimbabwe and the ancient mining industry and the terraced cultivation, that are so closely wrapped up therewith, is solved. We can only say that light is dawning where, previously, hasty conclusions thwarted deliberate investigation. There can be no question that even though portion of the ancient mining industry reaches into that epoch when bronze was the summit of metallurgical achievement and when micaceous iron and ochre had commercial significance, the industry in this country has nevertheless seen many phases. Just as in modern times the Witwatersrand succeeded Barberton as a mining centre and Rhodesia and Katanga followed in the wake of the Rand, so it is more than likely that the recovery of metal in such widely distributed areas as the copper-fields of Pandamacua in Portuguese East Africa, the early gold-fields of Rhodesia, the tin-mines of Rooiberg (Transvaal) and the old copper-mines of Katanga, was not being carried on at the same time. The evidence at present is only known in its broadest outline, and we await the skilful observation over the whole field that requires to be done before final conclusions can be reached and the different phases and periods of the industry isolated. Such work, as Frobenius on the one hand and Miss Caton Thompson on the other, are now carrying out with their skilled assistants, may be expected to reveal numerous and possibly still more complicated aspects of the entire Zimbabwe question.

The significance of the ancient mining industry and the movements and traffic of peoples which it connotes, for the understanding not only of the ruins but of all stone circles, stone huts and primitive architectural effort generally throughout the country, none of which are characteristic of man before the metal period, can scarcely be overrated. The weaving, agriculture, pottery making and other domestic arts associated in Europe with the Neolithic and metal-using phases of culture have as yet received little study from the point of view of

distribution and origin. It can, however, be but a matter of time before the stimulus arising out of the establishment of Departments of African life and languages in the various universities and colleges will find expression in numerous additions to our growing knowledge.

With respect to tribal folk-lore, music, organization, law and ritual more is understood, and the investigations of Mrs. Hoernle, Goodwin, Miss Werner, Prof. Kirby, Prof. Brookes, Lestrade, Miss Bleek, Miss Earthy and others in this field is extending worthily the initial investigations of Junod and other missionaries into these important phenomena and their relationships to similar systems in Northern Africa and elsewhere. In the field of South African languages, the work of Doke, Miss Werner, Bryant and others is rapidly expanding the early and important contributions of Bleek, Jacottet and Colenso. With the further growth of facilities in the several universities of departments devoted entirely to these studies, the insistence on a knowledge of native languages for entrants to the missionary field, the encouragement of native education in its own language medium, and the establishment at Fort Hare of a native college of university status, we may anticipate striking contributions in this sphere during the coming period and the building up of a body of knowledge concerning the African languages which will illuminate not only their relationship to one another, and incidentally explain many obscure points concerning the movements of the Bush and Bantu peoples, but will also assist us in learning what connections exist between the African languages and those of Europe on the one hand and those of Asia on the other.

Not least important amongst the future developments in this field will be the comparison of Bantu languages with those of Madagascar, whose Polynesian and Arabic

Plate 36.] BUSHMAN ENGRAVING.

[*From a rubbing by Miss M. Wilman.*

affinities have formed the subject of previous investigations. The influence of Arabic in the Swahili language and other languages of the east coast, although recognized, is far from being completely understood, and it can only be anticipated that the growth of philological research will, in Africa, as in Europe and the East, provide important corroborative knowledge to physical and social anthropology on many matters which, in the absence of information, can at present only be conjectured.

It will be recognized from what has been written, that remarkable as the progress in South African anthropology has been and particularly in the last decade, the advances made are superficial and small compared with the promises that loom on the horizon of every branch in this extensive avenue of scientific enquiry. We stand to-day on the threshold of an enormous and increasing development. The universities and museums now founded in South Africa, training and equipping South Africans for the understanding and unravelling of the secrets of their own land, will render the country increasingly independent of the necessarily spasmodic and discontinuous and adventitious labours of occasional investigators from Europe and elsewhere.

Such visitors, welcome and necessary as they are to the stimulation and frequently to the direction of different lines of enquiry, cannot possess the same attitude or assimilate the same exactitude of knowledge as necessarily results from the uninterrupted labours of a lifetime on the spot. It is, consequently, to South Africans that science will increasingly and confidently look for the development of South African anthropology. The fact that most of the advances above referred to have been directly due to South Africans or to those who have made South Africa their home, is a happy augury that this confidence will not be misplaced, and that the coming quarter of a century will reap a still richer and vaster harvest than did its predecessor.

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Plate .]

BUSHMAN PAINTING.

[*Traced by Miss M. Wilman.*

XV.

MEDICAL RESEARCH.

An Account of The South African Institute for Medical Research.

By SIR SPENCER LISTER, M.R.C.S., L.R.C.P., Director.

Prior to the year 1912, the provision for carrying out laboratory investigations in connection with medical practice in the Transvaal was quite limited.

Johannesburg was then but 25 years old, and the vigour and enterprise of its inhabitants had been mainly directed to the winning of gold.

At that time, medical laboratory investigations were confined to such procedures as could be carried out at the Government Chemical and Bacteriological Laboratories, situated in De Korte Street, on Hospital Hill; this designation was a somewhat grandiloquent description of what was, in reality, a badly ventilated, ill-lit, corrugated iron structure, divided into a number of partitioned-off compartments, wherein, nevertheless, much valuable routine work was carried out under great disadvantages. The staff, on the medical side, consisted of two medical men and four technical assistants, a considerable portion of whose time was occupied in medico-legal investigations.

The rapid advances in bacteriology of those times, and special circumstances surrounding the huge native, and, to a less extent, the European, labour organization of the Gold Mining Industry brought the whole question of medical services prominently before the minds of the leaders of the Industry.

The severe mortality, more particularly from lobar pneumonia and meningitis, amongst the tropical native labourers recruited from north of latitude 22° was causing grave concern, and the expenditure of large sums of money in improved housing, feeding and clothing had failed to bring about any significant improvement.

The success that had already attended the introduction of the prophylactic inoculation against enteric fever, and the increasing promise of beneficial results through the use of vaccines and sera in general, were beginning to impress both medical and lay opinion in Johannesburg. Further encouragement to this trend of thought was afforded by the example of the magnificent Government Veterinary Research Laboratories at Onderstepoort, outside Pretoria, under the energetic and able directorship of Dr. Arnold Theiler (now Sir Arnold Theiler). It was but natural that those responsible for the welfare of the labour force on the gold mines should visualize the establishment of some similar institute for the investigation of human diseases, with a view to their prevention and treatment. It was a fortunate circumstance, at this time, that there were influential representatives of the Mining Industry who were especially interested in health matters. Dr. Samuel Evans, Chairman and Managing Director of the Crown Mines, Ltd., who for some years had taken a prominent part in ventilating the necessity for giving greater attention to this aspect of the Industry's organization, had recently visited the Panama Canal to see the wonderful work in preventive medicine then being carried out under the leadership of General Gorgas; he, together with Mr. P. Ross Frames (subsequently Chairman of De Beers Consolidated Mines, Ltd.), who had likewise always evinced a particularly keen interest in the health of the labour force on the mines, and who was destined to become the first Chairman of the Board of the Institute, took a notable part in the early work that led to the

founding of the Institute. They gained the ready support of the late Sir Julius Wernher and Sir Lionel Phillips, whose services in the future developments which took place, were invaluable. In the medical profession also, there were men of vision who were alive to the necessity for a great expansion of the available medical laboratory services in South Africa ; amongst their number were the late Sir Kendal Franks, the late Dr. George Turner and Dr. Watkins-Pitchford.

Whilst the ideas of these and other enthusiasts were being formulated with a view to taking further action, Sir Almroth Wright visited Johannesburg at the invitation of the Mining Industry, on a mission of investigation into the prevention and treatment of lobar pneumonia, and his presence provided a further inspiration and stimulus towards the furtherance of a scheme already adumbrated for the founding of a medical research institute in Johannesburg. All these influences culminated in the Mining Industry approaching the Government in 1911, and requesting that up-to-date, well-equipped research laboratories should be established.

The Government at that time finding it impossible to accede to this appeal, the Mining Industry again approached it with an offer to build and equip an Institute for Medical Research, subject to certain conditions to be agreed upon. This generous offer was at once accepted, and, after prolonged negotiations necessary to settle the conditions to be observed by the two parties, an Agreement was reached in 1912, whereby the South African Institute for Medical Research was established.

The purposes of the Institute are set forth in the agreement as follows:—

(a) The Institute is founded and established primarily for the purpose of conducting researches and investigations, with a view to the prevention

and treatment of human diseases, including researches and investigations:

(*i*) into the causes, and the methods of diagnosis, prevention, and the treatment of human diseases; and

(*ii*) in the fields of pure and applied bacteriology, pathology, parasitology, pharmacology, and other branches of the medical and allied sciences.

(b) The Institute may, in addition, undertake public health, medico-legal, pathological, bacteriological, serological, clinical, and other routine examinations, investigations and procedures, and all such work as is ordinarily carried out in a public health laboratory; and may manufacture, purchase, and supply or sell all such vaccines, sera, and other preparations, products, appliances and material as may from time to time be approved by the Board.

The Institute occupies a commanding site, in extent just over six acres, adjacent to the Johannesburg Hospital and the Medical School of the University of the Witwatersrand, and overlooking the central area of Johannesburg. The site for the buildings was donated by the Government, whilst the cost of the original buildings and their equipment, and the lay-out of the grounds, amounting to over £46,000, was borne entirely by the Witwatersrand Native Labour Association.

The building was completed and occupied in August, 1914. The Institute's activities expanded so rapidly, that, from 1924 to 1927, additional buildings were added and equipped at a cost of approximately £35,000, towards which the Government made a grant of £20,000 in view of the accommodation provided in the original buildings for the Miners' Phthisis Medical Bureau, which falls under

the administration of the Union Department of Mines and Industries. At the present time (1929) further laboratory and stable accommodation is in course of construction, at an estimated cost of £20,000, to meet the demands of the Institute's increasing work.

The main building is of basement and two storeys of lofty proportions, and designed with the feeling of English Renaissance. In general, it is planned about three courts or quadrangles. The first court is open upon the eastern side, and faces the main approach, which lies through expansive lawns planted with ornamental trees. The second court is screened from the first by an open colonnade, through which are seen palms and orange trees, and a low fountain set in grass lawns. Behind, in central vista, rises a columned dome, surmounted by a bronze finial by Broadbent, indicative of the "Triumph of Science over Decay and Death." The third court, lying behind the dome, is enclosed on all sides, the northern side being of one storey in height for the better admission of sunshine.

As far as possible, all the laboratories have been given a southern aspect for steady light, while offices, library, clinical wards and staff rooms are towards the sun. The northern wing accommodates the Miners' Phthisis Medical Bureau, the Institute occupying the whole of the remainder of the buildings.

Although housed in a portion of the Institute buildings, the Miners' Phthisis Medical Bureau is an entirely separate organization; it is usual, however, to include within a tour of the Institute, a visit to the Bureau, the work of which is highly interesting.

In addition to the laboratories and administrative offices, the equipment of the Institute includes a Medical library, pathological museum, lecture theatre, refrigerating plant with complete cold storage rooms, other accessory store rooms and workshop. Separate

from the main building, but standing in the grounds, are the residence of the Director, Caretaker's cottage, stables for 30 horses, with animal operating room and laboratory, small animal houses, post-mortem and isolation laboratories.

The main building was designed by the architect, Mr. (now Sir) Herbert Baker, A.R.A., F.R.I.B.A., and carried out under the supervision of the firm of Messrs. Herbert Baker and Fleming, of Johannesburg. The architect for the later additions was Mr. F . L. H. Fleming, of Johannesburg. The builder for the whole of the work was Mr. John Barrow, of Johannesburg.

The Institute is controlled by a Board consisting of six members, three of whom are nominated by the Union Government, and three by the Witwatersrand Native Labour Association, the technical administration being in the hands of the Director.

The first Director of the Institute was Dr. W. Watkins-Pitchford, who, by his foresight, his scientific and administrative ability, brought it to a position where its future progress and usefulness were assured. He held the appointment until 1926, when ill health was responsible for his much regretted resignation.

Although administered as a single body, the Institute is organized in two distinct technical divisions, known, respectively, as the " Research Division " and the " Routine Division," the income of each of which is derived from separate sources. The " Research Division," as its name implies, is concerned entirely with original research work, *i.e.*, the advancement of medical knowledge in matters yet unsolved. The " Routine Division," on the other hand, is mainly concerned with the application of already known and accepted principles and procedures in the diagnosis and treatment of disease, with university teaching in the medical faculty, with the carrying out of public health,

Plate 38.] THE SOUTH AFRICAN INSTITUTE FOR MEDICAL RESEARCH.
VIEW FROM THE SOUTH.

medico-legal, and such-like investigations, and with the preparation of bacterial vaccines, antitoxins and other sera.

The cost of maintenance of the " Research Division " of the Institute is borne by the Union Government and the Witwatersrand Native Labour Association in equal proportions, up to a limit of £15,000 per annum. Much more than this could be utilized profitably in extending the work and adding to the personnel of the Division, and it is to be hoped that the " official " income of the Division may be supplemented by private benefactions, to an increasing degree. Up to the present about £20,000 has been donated or bequeathed to the Institute, and forms the nucleus of a Research Endowment Fund.

The expenditure on the " Routine Division," on the other hand, is met entirely by the revenue earned by the Division for the laboratory services rendered to Government Departments, municipalities, hospitals, mines and the medical profession, and from the sale of vaccines and sera ; any surplus revenue earned by this Division is transferred to the Research Endowment Fund, or is used for further capital expenditure necessitated by the expansion of the Routine Division.

The " Research Division " at present comprises departments of Bacteriology, Parasitology, Industrial Hygiene, Bio-chemistry and Medical Entomology.

A prominent line of research which has been pursued in the Division, is that concerning the prevention of lobar pneumonia amongst the native labourers employed on the mines. This disease, until recent years, accounted for much of the illness and mortality amongst these labourers, but, as a result of investigations carried out over a long period at the Institute, a method of preventive inoculation against this disease was devised, and is now applied to all natives recruited for work on the gold and diamond mines.

Silicosis, which is by far the most important industrial disease in South Africa, has been the subject of extensive investigation at the Institute. Apart from its medical aspect, its economical significance will be easily realized by stating that the monetary compensation paid to affected miners by the Gold Mining Industry, under the Miners' Phthisis Act, amounts to £800,000 per annum. It is true that this sum includes the expenditure in connection with tuberculosis, nevertheless the activities of the *B. tuberculosis* are so closely associated with silicosis, that the problem cannot be attacked without taking both factors into account. Through its provision of the official pathological service to the Miners' Phthisis Medical Bureau, the Institute has constantly had available a wealth of material for study.

Investigations have covered a wide field, including studies of the size and character of siliceous particles concerned in the production of silicosis, animal experimentation with various other varieties of dusts to determine their significance in the production, and even in the prevention, of pulmonary disease, the influence of bacterial infective agents in the aetiology and development of silicosis, detailed studies of its gross pathology and of its morbid histology, together with a number of statistical enquiries undertaken with a view to the formulation of hypotheses and the throwing of light upon the epidemiology of the disease. Work more immediately concerned with the prevention of silicosis has been the study of methods for eliminating the dust of silica from the air, and a consideration of the advantages and disadvantages of the use of water for this purpose.

The Institute is kept in constant touch with the practical aspect of this disease through its representation on the Government Miners' Phthisis Prevention Committee and the Chamber of Mines Dust Sampling Committee.

The work already carried out in connection with this disease is recorded in a number of publications, and has received world-wide recognition.

The widely spread infection of plague amongst veld rodents in South Africa, leading to occasional cases of bubonic and pneumonic plague in human beings, has called for continuous investigation by the Institute's research staff, and a great deal of attention has been devoted to both field and laboratory study of the rodents themselves, their ecto-parasites, and the *B. pestis*. Much of this work has been carried out at the request of, and in collaboration with, the Public Health Department of the Union.

Malaria, although practically non-existent in Johannesburg, is a serious menace to health in certain districts of the Union, and the entomological staff of the Institute has, in recent times, conducted mosquito surveys in the Northern Transvaal, along the coastal belt of Zululand, and elsewhere. The accumulated knowledge, prior to these investigations, regarding the distribution of mosquitos in South Africa was singularly meagre, and but little was known of their complete life history and their habits at all stages of their development in this country. These comprehensive and extensive surveys have now placed us in possession of much valuable information essential in the devising of methods of mosquito destruction capable of being economically carried out at the most vulnerable period of their existence.

Bilharziasis, or "human red water disease", is prevalent in many country districts throughout South Africa, and is alleged, with good reason, to be the cause of a retardation of both physical and mental development in many of the children who live in the affected areas. The parasite responsible for this infestation is a Trematode, *Schistosoma haematobium*, part of whose life history is related to its development in certain fresh water snails,

of which *Physopsis africana* is the most common host. The cercariae of this parasite are liberated from the infected tissues of these snails into pools of water and slowly-flowing streams, and, as free swimming organisms, penetrate the skin of adults or children bathing therein, and subsequently develop, in their bodies, into adult worms which deposit their eggs in the submucosal lining of the bladder. The irritation caused by the passage of these eggs through the bladder tissues gives rise to chronic inflammation and haemorrhage. The parasitological staff of the Institute has made extensive surveys of many parts of South Africa, and has acquired accurate knowledge of the distribution and habits of these infested and other molluscs. This disease is of such importance that camps have been organized, through the Transvaal Educational Department, in certain outlying areas where the disease is rife, in order to secure the attendance thereat of affected children to undergo a course of curative treatment. In this connection, the Institute has produced a "cinema film", illustrating the main points in connection with this disease, to be used for the purpose of propaganda.

In addition to these diseases more especially particularized, rabies, dengue fever, hookworm disease, amoebic dysentery, cerebro-spinal fever, tuberculosis, hay fever, epidemic influenza, cell growth *in vitro*, cancer and bio-chemical investigations are some of the subjects that occupy the attention of the Research Division staff, in addition to studies in the domain of pure bacteriology. These investigations are recorded in the Institute publications or in contributions to technical journals by members of the staff.

At the present time a comprehensive investigation, under the control of the Institute, is being made of tuberculosis, especially in its relation to the native and coloured races in South Africa. The project was initiated

Plate 39.] THE SOUTH AFRICAN INSTITUTE FOR MEDICAL RESEARCH.
VIEW OF THE EAST FRONT.

by the Transvaal Chamber of Mines, who appointed an Advisory Committee, upon which the Institute is represented by three members, including the Director, who is Chairman. As an outcome of the deliberations of the Committee (now known as the Tuberculosis Research Committee), it was recommended, amongst other things (1) that an extensive tuberculosis survey be organized and carried out in the native territories and elsewhere under the direction of an epidemiologist, with special experience in tuberculosis work, assisted by an experienced tuberculosis officer for field work, together with laboratory services; and (2) that financial provisions be made for carrying on this work for a period of three years. These recommendations having been brought to the notice of the Chamber of Mines, the Union Government, and the Board of Control of the Deferred Pay (Natives') Interest Fund, all three bodies undertook to contribute £2,000 per annum for three years (£6,000 per annum in all) towards the cost of the scheme, subject to its administration and control being vested in the Institute with the co-operation of the Tuberculosis Research Committee. In this connection the Institute was fortunate in securing, as chief consultant and adviser, Colonel S. Lyle Cummins, C.B., C.M.G., now Professor of Tuberculosis at the University College of South Wales. For the field work in the native territories and elsewhere, the Government very kindly consented to second to the Institute Dr. Peter Allan, Medical Superintendent of the Nelspoort Tuberculosis Sanatorium. This investigation has branched out into many channels entailing much team work in which a number of members of the Institute's staff are taking a leading part.

A perusal of this brief account of the activities of the Research Division is sufficient evidence of the ample material at its disposal for investigation, and the necessity for the existence of such an organization in South Africa.

The work of the " Routine Division " consists of the performance of bacteriological examinations in connection with the diagnosis of enteric, undulant and typhus fevers, diphtheria, tuberculosis, plague, etc. ; serological and bio-chemical tests ; examinations for presence of parasites in the diagnosis of malaria, dysentery, sleeping sickness ; the bacteriological examination of water, milk and foods ; the bacteriological testing of the efficiency of disinfectants ; the histological examination of pathological specimens, the performance of medico-legal investigations in charges of murder and rape, and the giving of expert evidence thereon. The extent and progressive increase of this side of the Institute's work may be gathered from the following table, showing the number of laboratory examinations carried out in the " Routine Division " over a period of twelve years. This table, it should be noted, does not include the investigations of the " Research Division," which do not lend themselves to similar methods of record.

Year	1914	No. of Routine Investigations			.. ..	9,091
,,	1915	,,	,,	,,	.. ..	9,804
,,	1916	,,	,,	,,	.. ..	15,061
,,	1917	,,	,,	,,	.. ..	18,250
,,	1918	,,	,,	,,	.. ..	21,035
,,	1919	,,	,,	,,	.. ..	17,808
,,	1920	,,	,,	,,	.. ..	18,347
,,	1921	,,	,,	,,	.. ..	23,192
,,	1922	,,	,,	,,	.. ..	27,432
,,	1923	,,	,,	,,	.. ..	35,537
,,	1924	,,	,,	,,	.. ..	41,833
,,	1925	,,	,,	,,	.. ..	52,844
,,	1926	,,	,,	,,	.. ..	65,980
,,	1927	,,	,,	,,	.. ..	77,469
,,	1928	,,	,,	,,	*circa*	100,000

The work of the " Routine Division " of the Institute covers a wide field ; in addition to the numerous procedures carried out, chiefly for diagnostic purposes, on

behalf of Government Departments, municipalities, mines, hospitals and the medical profession, the Institute provides the pathological services for the Johannesburg General Hospital, which include the performance of post-mortems, which number about 500 per annum, and also pathological services to the Miners' Phthisis Medical Bureau, involving, amongst other investigations, the examination of more than 600 lungs annually. Three years ago, an arrangement was arrived at whereby the teaching and the development of the Department of Pathology in the Medical School is carried on by the staff of the Institute. For undergraduates, classes in the following subjects are held : pathology, bacteriology, parasitology, clinical pathology and surgical pathology. In addition, instruction in post-mortem technique and morbid anatomy is carried out during the autopsies done on behalf of the General Hospital, Johannesburg.

Associated with the development of medical post-graduate teaching and the institution of diplomas in public health, in tropical medicine and in psychological medicine, courses in bacteriology, parasitology and pathology are conducted in the Institute's laboratories. Demonstrations are also given, at the Johannesburg Hospital, of routine methods in connection with the course on clinical pathology instituted for the resident medical officers, and, in addition, the staff acts in the capacity of clinical pathologists to this institution.

A further activity of the " Routine Division " is the preparation, on a large scale, of bacterial vaccines and sera for use in the prevention and treatment of many diseases. In the preparation of sera (obtained from horses immunized against diseases for which their blood-serum is then used as a curative agent) a complement of over 30 horses is used.

The preparation of vaccines and sera has grown from small beginnings until it now entails the preparation of

more than a million doses of these products annually. In the Serum Department, all the commonly used anti-sera are prepared, including both anti-toxic and anti-bacterial sera ; here also are prepared the materials for carrying out the Schick Test for the identification of those persons who are susceptible to infection by the *B. diphtheriae*, together with the bacterial product known as anatoxin (Ramon), which is used by the method of subcutaneous injection to produce immunity in individuals susceptible to infection by the bacillus of diphtheria.

The variety of the services provided for, the ample material available, and the size of the staff enable the officers of the " Routine Division " to interest themselves in problems which are usually outside the scope of a purely routine clinical laboratory. Thus, recently, members of this Division have, amongst other special investigations, conducted an extensive research in connection with a disease variously termed sweating sickness, or military fever, which occasionally affects native mine labourers, often with a fatal result. The therapeutic value of bacterial filtrates, or antivirus preparations, introduced by Besredka, has also been the subject of investigation. Pulmonary asbestosis has been studied, and the pathology of thrombo-angiitis obliterans ; experimental studies are in progress with a view to determining whether early silicotic nodules in cases of human silicosis are infected with the tubercle bacillus before the typical tuberculous lesion manifests itself, and concerning the case-incidence of blood vascular disease, with special reference to atheroma in young subjects. It will thus be realized that there is no hard and fast line of demarcation as regards original investigations between the members of the " Routine " and " Research " divisional staffs, although the members of the latter have, of course, far more time at their disposal for such purposes.

The foregoing description of the Institute's work shows the rapid expansion that has occurred, and is still

Plate 40.]

THE SOUTH AFRICAN INSTITUTE FOR MEDICAL RESEARCH.
RESEARCH LABORATORY FOR INDUSTRIAL HYGIENE.

continuing, in all its departments, and coincident with this there has been a corresponding increase in the staff. In the early days of its history there were but three qualified officers including the first Director, Dr. W. Watkins-Pitchford, together with three technical assistants, three clerical assistants, and seven native servants. To-day there are eighteen qualified officers with twenty-five technical assistants, seventeen administrative and clerical officers, twenty-eight native servants and one Indian stableman. This evolution indicates the need for such an Institute in South Africa, and its future seems to be well assured.

Thus the foresight and aspirations of those responsible for the foundation of the Institute, in order to promote the cause of medical research in South Africa, have been amply justified, and, to a great extent, realized. No longer does South Africa carry the reproach, at one time justifiably levelled at it, of neglecting research into the problems of human diseases whilst providing amply for the investigation of those of animals. In the short space of fifteen years since the Institute buildings were completed, which included the war years with all the attendant handicaps, it may be claimed for the Institute that it has established a reputation which is by no means confined within the borders of the Union, and it is not too much to hope that by its means the Union of South Africa may vie with older established countries in adding materially to the sum of human knowledge of the diseases that affect mankind.

XVI.

COMMERCE AND INDUSTRIES.

By The Board of Trade and Industries.

Commerce.—Since the establishment of Union in 1910, there has been a remarkable development in commerce and industry in South Africa. There have also been notable changes in the commercial and industrial organization of the Union.

The value of the overseas trade of the Union, imports and exports combined, rose from £90,000,000 in 1910 to £170,000,000 in 1927, and to £176,000,000 in 1928. When this increase in overseas trade is considered in conjunction with the fact that a much larger proportion of our requirements is now produced or manufactured locally, and that the gross value of the output of our factories and workshops has grown from £17,000,000 in 1911 to almost £98,000,000 in 1926-27, the extent of the expansion which has taken place in the commercial and industrial activities of the Union may be appreciated. It is true that between 1910 and 1928 there was a rise of from 30 to 40 per cent. in the general price level, and that, consequently, all values are to be regarded as inflated by approximately that margin ; but even when due allowance is made for this rise in prices, it is apparent that there has been considerable growth of economic activity.

Exports.—The exports (including ships' stores) have advanced from £54,000,000 in 1910 to £96,000,000 in 1927, and about £97,000,000 in 1928. The great bulk of our exports consists of minerals and of agricultural or pastoral produce. The products of mines still account for the greater proportion of our exports, but in recent

years the proportion of farm produce has increased owing to the rapid expansion of agriculture and stock farming, as illustrated in the following table :—

EXPORTS OF THE UNION (1910-27).

Year.	Products of Mines.	% of Total.	Agricultural and Pastoral Produce.	% of Total.	Other Products.	% of Total.
	£	%	£	%	£	%
1910	41,996,000	78	9,485,000	18	2,128,000	4
1916	48,586,000	74	12,916,000	20	4,181,000	6
1923	52,965,000	65	22,613,000	28	5,469,000	7
1927	60,300,000	63	28,000,000	29	8,000,000	8

The foregoing table shows clearly that, while there has been a substantial increase in the exports of all three groups of products, the relative position of minerals in the export trade of the Union has steadily declined since 1910. On the other hand, there has been a highly gratifying growth in the exports of farm produce. When it is borne in mind that practically the whole of the mineral output is exported from the Union, whereas a large proportion of the agricultural and pastoral production is consumed locally either directly or through local manufacturers, and that, consequently, an appreciable part of the increased output of farm produce has been absorbed by the increase in population, it becomes abundantly clear that a significant change has been brought about in the domestic economy of the Union. However, although now of less importance in the total volume of local production than was the case in 1910, mineral products still dominate the export trade and supply the greater part of the Union's purchasing power abroad.

Gold is the principal export of the Union, representing in 1927 45 per cent. of the total value of our exports. In this respect the Union occupies a unique position in international trade. Moreover, gold represents one of the most stable items in our export trade. There has

been a steady increase in the gold production of the Union, and with occasional exceptions, the whole of the gold output is exported either as bullion or specie. Of the increase of £18,300,000 in the value of our mineral exports between 1910 and 1927, gold accounted for £11,700,000 and diamonds £3,800,000. There was also an increase of £2,000,000 in bunker and export coal, and of £180,000 in tin. Copper is the only mineral export which suffered a decline, namely, from £490,000 to £477,000.

In recent years attention has been paid to various other base mineral propositions in the Union. The export of asbestos developed from £26,000 in 1910 to £189,000 in 1927, and that of chrome, fluorspar and corundum from practically nothing to £43,000, £13,000 and £9,000, respectively. The export trade in these minerals is expanding slowly at present, owing to various obstacles and difficulties which have to be overcome in the initial stages, but they offer great possibilities for future development. Furthermore, the exploitation of such minerals as manganese and antimony is about to be undertaken on a relatively large scale.

Other recent developments of mineral exports are those of platinum and osmiridium, which amounted to £144,000 and £54,000 respectively in 1927.

The following table shows the increases and decreases of exports of agricultural and pastoral produce during the last eighteen years :—

INCREASES IN EXPORTS.

Article of Export.	1910. £	1927. £	Increases. £
Wool	3,800,000	17,100,000	13,300,000
Hides and skins	1,010,000	3,787,000	2,777,000
Maize and maize products	740,000	2,050,000	1,310,000
Wattle bark and extract..	220,000	1,160,000	940,000
Fresh fruit	37,000	825,000	788,000
Sugar	38,000	784,000	746,000

Article of Export.	1910. £	1927. £	Increases. £
Eggs	—	225,000	225,000
Fresh meat	8,000	179,000	171,000
Cotton	—	170,000	170,000
Dried fruit	—	163,000	163,000
Tobacco	19,000	116,000	97,000
Spirits, wines and grape juice	20,000	92,000	72,000
Canned fruits	—	68,000	68,000
			20,827,000

DECREASES IN EXPORTS.

	£	£	Decrease. £
Ostrich feathers	2,273,000	44,000	2,229,000
Mohair	903,000	808,000	95,000
			2,324,000

Of the net increase of about £18,500,000 in the exports of agricultural and pastoral products, wool alone contributed £13,300,000. This marked increase is to be attributed in almost equal proportions to the growth in the volume of wool exports from 122 to 260 million lb., and to the rise in the average price obtained for wool in the grease from 7d. to 1s. 3d. per lb. It has been a powerful factor in increasing the purchasing power of a large body of farmers in the Union, and as the wool production has been growing rapidly in recent years, it will no doubt retain its place as one of the mainstays of the country.

As in the case of gold and most of the other minerals, the great bulk of our wool production is exported every year, the quantity taken by the local blanket factories being comparatively small. The same applies to wattle bark and extract, of which only about £40,000 worth per annum is used by the local tanneries, and to cotton, of which hardly anything apart from the seed is, as yet,

consumed in the Union. To a smaller extent this also holds true for hides and skins, of which about £500,000 worth is annually absorbed by local tanneries compared with an export of £3,787,000 in 1927.

The exports of maize and maize products, however, usually amount to about one-third only of the local production. This applies also to such articles as sugar, fresh and dried fruits and eggs, while in the case of fresh and preserved meats, tobacco, spirits and wines the exports represent a very small proportion of the local production; our export trade of these products was negligible in 1910. There has been a comparatively rapid development in these lines during the last ten years, and there are reasonable possibilities for future development.

Decreases in exports have taken place only in the case of ostrich feathers and mohair, especially the former, the export of which has dwindled from over £2,000,000 to practically nothing. Mohair showed only the small decrease of about 10 per cent. As regards the future, the prospects do not appear to be bright for either of these two products.

The principal items grouped under the term "other products," are imported goods re-exported to other states and territories in South Africa, and locally manufactured goods exported to these neighbouring countries, which latter development bids fair to assume important dimensions in the future. Further items of importance are the exports of fish, crayfish, whale oil and whale guano and other by-products of the whaling industry, which amounted in 1927 to £89,000, £203,000, £330,000 and £112,000 respectively.

Imports.—The imports (including Government stores) have likewise grown considerably, and were doubled between 1910 and 1927, namely, £37,000,000 and £74,000,000 respectively, rising still further to £79,000,000 in 1928.

Our imports consist primarily of manufactured articles, composed mainly of clothing and other textile goods, and machinery or other metal manufactures. The imports of clothing and other textile goods advanced from about £9,000,000 in 1910 to £18,300,000 in 1927, *i.e.*, an increase of 103 per cent., but in the case of apparel and slops (including underclothing, hosiery, hats and caps, but excluding boots and shoes), there was an increase of only 80 per cent., namely, from £3,250,000 to £5,900,000. This is to be attributed principally to the development of the clothing industry in the Union, which is further illustrated by the increase in the imports of cotton and woollen piece goods from £1,880,000 to £5,000,000. Piece goods are not yet manufactured locally, but the manufacture of clothing, and of outer garments in particular, is expanding rapidly, and, consequently, a further increase in the imports of piece goods may be expected. There was also a considerable increase in respect of jute or other bags for grain, coal, wool and other local produce, the imports growing from £340,000 to £1,200,000. Jute and hessian, as well as cotton, bags are being made in the Union on a small scale from imported bagging or other materials in the piece.

The imports of metals, machinery, vehicles and other metal manufactures, rose from £10,700,000 in 1910 to £24,300,000 in 1927. Of the latter figure machinery, implements and motor vehicles accounted for £11,000,000, the imports of machinery and implements having been £6,000,000 and those of motor vehicles £5,000,000. In connection with the former it may be noted that, while there was an increase in the imports of agricultural and industrial machinery and implements, and also of electrical machinery and appliances, there was a slight decrease in the importations of mining machinery, the imports of which, however, exceed £1,000,000 every year. The imports of motor vehicles, in keeping with movements in other parts of the world,

have increased from £310,000 in 1910 to £5,000,000 in 1927; since the expansion of motor transport will probably continue, the present imports are likely to be maintained if not increased. In the case of metals, the imports of raw or semi-manufactured iron and steel, such as ingots, billets, bars, rods, angles, channels, plates, flat sheets and drill or tool steel, increased from about £600,000 to £1,300,000 in spite of the fact that pig iron and steel have in recent years been turned out locally on an increasing scale. It is expected that when the Pretoria Iron and Steel Works begin production, the imports of iron and steel will show a substantial decline. The imports of iron and steel have grown with such rapidity largely as a result of the expansion of our engineering workshops and foundries, while for the same reason the imports of various metal manufactures do not show an increase commensurate with the average increase.

Among the other items of import which have undergone noteworthy increases in recent years may be mentioned, firstly, motor spirit, paraffin and lubricating oils, the imports of which rose from £420,000 in 1910 to £2,300,000 in 1927; secondly, motor tyres and tubes, which amounted to over £1,000,000 in 1927 compared with about £30,000 in 1910; and thirdly, jewellery, gold and silver plate, clocks and watches, fancy goods, sporting and athletic goods, toys, musical instruments, photographic apparatus and materials, cinematograph films, and tobacconists' wares, which together accounted for £2,000,000 of the imports in 1927. Among imports other than those already mentioned, which have declined during the past twenty years in spite of the considerable increase in population and consumption as well as in values, or which have not increased at nearly the average rate, the following may be mentioned: Boots and shoes, the imports of which declined from £1,190,000 to £950,000; furniture (wooden and metal), from £360,000 to £160,000; printed matter and stationery, soap,

candles, confectionery, jams and jellies, biscuits, chemicals, matches, etc. In these cases, local industries supply most of the requirements of the Union.

There are several articles which were regularly imported into South Africa prior to 1910, but which are now either not imported or are imported in only small quantities, and usually of a special kind or quality, namely, butter, cheese, eggs, bacon and ham, frozen meat and sugar. In the case of sugar, meat and eggs, a substantial export trade has been developed in recent years, and exports of the others take place from time to time.

Finally, the Union has to import various articles of food and drink, such as wheat and flour to the amount of £1,700,000 in 1927, which represents about one-third of local requirements; rice to the amount of £629,000; coffee about £1,000,000; tea, £900,000; condensed milk, £300,000, etc.

Local Industries.—The manufacturing industries of the Union have advanced from a gross output of £17,000,000 in 1911 to £40,000,000 in 1915-16, £80,000,000 in 1923-24 and £98,000,000 in 1926-27.

Prior to 1910, a large number of subsidiary branches of industry had come into existence under the stimulus of the mining industry or of the revenue duties, or both, but most of these were conducted on a relatively small scale. Between 1910 and 1914 over 1,600 new factories were established, and representations were made to Government with a view to securing higher duties on various articles, some of which were incorporated in the Customs Tariff Act of 1914. However, although a beginning had undoubtedly been made, and the way had been prepared for an expansion of manufacturing operations, it was not until after the outbreak of the World War, which threw South Africa on its own

resources and gave an abnormal impetus to local industries through higher freight and insurance charges as well as lack of shipping accommodation, that the more important branches of industry and manufacture were established on a fairly large scale. Moreover, customs duties were raised in several instances for the sake of providing an increased revenue to cover the increased expenditure, but, incidentally, had the effect of enhancing the protection enjoyed by manufacturing enterprises.

The result of the combined operation of these factors was that, with the outbreak of war in 1914, the Union entered an era of industrial development. The real extent and significance of the manufacturing industry are to be ascertained more particularly from the value added in the process of manufacture, *i.e.*, by deducting from the gross value of the output of the factories the cost of materials used. This net value of the industrial output, which represents the actual amount of manufacturing done in the Union, was increased from £18,000,000 in 1915-16, the first year for which such statistics are available, to £47,500,000 in 1926-27, or an increase of 164 per cent. in eleven years.

In the industrial development of recent years the fiscal policy of the Government has undoubtedly played an important part. Prior to 1925 provision had been made in the Customs Tariff for various protective and semi-protective duties, while many industries enjoyed a certain measure of incidental protection under the general *ad valorem* duty of 20 per cent. Under the revised Tariff of 1925, however, a policy of protection and encouragement of local industries was brought into effect. This took the form not only of increased duties on those finished articles the importation of which was found to cause serious detriment to the local manufacturers concerned, but also included the free admission, as far as possible, of raw or semi-manufactured materials which

were required for manufacturing purposes in the Union and could not be obtained locally. As it was realized that, unless protection to secondary industries was administered with caution and discrimination, it was fraught with great danger to the primary industries, the requisites of farming and mining were left untouched wherever possible, and in any case protection was applied and offset by reductions in revenue duties in such a manner as not to raise the cost of production as a whole in such industries, or even the cost of living in general.

The leading groups of industries in the Union, according to the method of classification adopted in connection with the industrial census are :—

(1) The manufacture of flour, bread, biscuits, cake, sweets, confectionery, jams, jellies, preserved fruit, preserved fish, preserved meat, ham and bacon, butter and cheese, sugar, mineral water, beer, wine, brandy, spirits, pipe and roll tobacco, cigarettes and cigars, etc. In 1926-27 the gross value of the output under this heading amounted to £30,800,000, and the net value £10,200,000 ; the main centre of this group is the Cape Peninsula, which ordinarily yields about one-fourth of the total production of such commodities.

(2) The operation of engineering works, foundries, steel works, tin or copper or iron-smelting establishments, mine or tramway or railway workshops, blacksmithing and plumbing establishments, wire works, gate and fence-making concerns, galvanised iron works, brass and copper works, etc. In 1926-27 the gross value of the output of this group of industries was £21,100,000, and the net value £10,600,000 ; the principal centre is the Witwatersrand, which accounts for almost one-half of the output.

(3) The construction of buildings, irrigation works, harbour works, sewerages and bridges, the gross value of the work done amounting to £9,400,000, and the net value £4,900,000 in 1926-27.
(4) The manufacture of explosives, fertilisers, soap, candles, matches, paints, varnishes, disinfectants, tanning extract, carbonic acid gas, grease, dips, insecticides and other chemicals, the gross value of the output being £6,400,000 and the net value £2,800,000 in 1926-27. Durban yields about one-third of the gross value in the Union, followed by the Witwatersrand and the Cape Peninsula.
(5) Printed matter, stationery, paper bags and cardboard boxes, the amounts being £4,800,000 and £3,500,000 respectively.
(6) Tailoring and ready-made clothing, millinery and dressmaking, dyeing and cleaning, blankets, mats, rope and twine, the amounts being £4,000,000 and £2,000,000 respectively.
(7) Leather and leatherware, the amounts being £3,500,000 and £1,300,000 respectively.
(8) Cement, bricks, tiles, lime, glassware, etc., the amounts being £3,200,000 and £2,500,000 respectively; and
(9) Furniture and cabinet-making, with a gross output of £2,000,000 and a net output of £1,100,000.

As examples of new industries which have been established during the past five years may be mentioned the manufacture of cotton blankets, felt hats, motor car bodies, petrol pumps, nails, bolts and nuts, cutlery, shovels, pig iron, cane trucks, baking powder, as well as several new branches of the chemical, leatherware and clothing industries. The following are the most important of the old-established industries which have made progress in recent years: ready-made clothing

(including shirts and pyjamas), sweets and confectionery, boots and shoes, printed matter and stationery, furniture, soap and candles, hose and other rubber goods, metal castings, cement, soda ash, condensed milk, bacon and ham, clay products and asbestos manufactures. They have made considerable headway, and most of them hold out great possibilities for future expansion.

About one-half of the raw or semi-manufactured materials used by local industries as the basis of their manufacturing operations is obtained from local sources, and the other half is imported. Thus, the expansion of local industries leads not only to a wider market in the Union for the local products of farming and mining, but also tends to increase the imports of such materials as are not obtainable in the country.

Owing to continual droughts, irrigation is perhaps one of the most pressing problems which the country has to face. The Government Department of Irrigation consisting of a Director and staff of engineers, have done excellent work in bringing some of the most fertile parts of the country under irrigation. The conditions under which such schemes have to be worked are generally difficult and complicated. In 1926, no fewer than 102 irrigation schemes were investigated by the department. Seventy-seven of these were completed at a cost of over 3½ millions sterling, the rateable area being 193,638 morgen.

Owing to certain difficulties which have faced manufacturers from time to time, development in the engineering industry has been mainly in the direction of the general jobbing shop. Apart from railway workshops, which number 75 in all, the turnover of the industry has increased by over £7,000,000 in the last eight years. Without railway workshops the present turnover of the industry approaches £10,000,000 which is 12·8 per cent. of the total industrial turnover of the country.